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HYGIENE:

A MANUAL

OF

PERSONAL AND PUBLIC HEALTH.

BY

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John William Rogerson

PREFACE

THE lapse of time, and the advance of Hygiene since the first issue of this work in 1884, have necessitated a thorough revision of its contents.

In the present edition, while the general arrangement of matter has not been altered, numerous alterations and additions will be found scattered throughout the book, and several new illustrations have been inserted.

At the end of the book will be found also a number of supplementary chapters, dealing chiefly with mathematical problems frequently occurring in Hygiene Examinations. These have been completely worked out, so that the student need have no difficulty in solving other similar problems. These chapters, and the additional chapter on Trade Nuisances, now enable the student in the Honors Stage of the Science Department to obtain all the necessary information from the present work, with the exception of Vital Statistics and Sanitary Law, on which special works are recommended in the supplement.

It is hoped that the book in its revised and enlarged form will be as widely useful as it has been in the past.

ARTHUR NEWSHOLME.

BRIGHTON,

CONTENTS.

HYGIENE.

CHAPTER I.

INTRODUCTORY.

The History of some Preventible Diseases.—The Amount of Preventible Disease.—Personal and Public Hygiene.

In classical mythology, Æsculapius was worshipped as the god of Medicine, while his daughter Hygeia had homage done to her as the sweet and smiling goddess of Health. The temples of these two deities were always placed in close contiguity; and statues representing Hygeia were often placed in the temple of Æsculapius. In these statues she is represented as a beautiful maid, holding in her hand a bowl, from which a serpent is drinking—the serpent typifying the art of medicine, then merely an art, now establishing its right more and more to the dignity of a science.

That considerable attention was paid in very early times to matters relating to health, is also shewn by the elaborate directions contained in the Mosaic law as to extreme care in the choice of wholesome foods and drinks, in isolation of the sick, and attention to personal and public cleanliness. It is not surprising to find as a consequence of this, that the Jews, throughout the whole of their history, have been comparatively free from epidemic diseases, and that the average duration of their lives has been apparently greater than that of other races.

In this country great ignorance of the laws of Health has until recent years prevailed, and consequently preventible diseases have been rampant, and have claimed innumerable victims. Each century has been marked by great epidemics, which have swept through the country, scattering disease and death in their course. In the fourteenth century, for instance, there was the Black Death, a disease so fatal that it left scarcely one-fourth part of the people alive; while Europe altogether is supposed to have lost about 40

millions of its inhabitants, and China alone 13 millions. A century and a half later came the Sweating Sickness (though there were a score of minor epidemics in between.) This was carried by Henry the Seventh's army throughout the country, and so great was the mortality, that "if half the population in any town escaped, it was thought great favour." Considerable light is thrown on the rapid spread of this disease after its importation, when we remember, that there were no means of ventilation in the houses; that the floors were covered with rushes which were constantly put on fresh without removing the old, thus concealing a mass of filth and exhaling a noisome vapour; while clothing was immoderately warm and seldom changed; baths were very seldom indulged in, and soap hardly used.

In the sixteenth and seventeenth centuries there were five or six epidemics of The Plague, and it was only eradicated from London, when all the houses from Temple Bar to the Tower were burned down in the Great Fire of September 2nd, 1666, which destroyed the insanitary houses, and necessitated the building of new and larger ones.

Scurvy, jail-fever, and small-pox, are other diseases which were formerly frightfully prevalent. Jail-fever, the same disease as the modern typhus-fever, has now become practically extinct in its former habitat, owing largely to the noble work of John Howard, "whose life was finally brought to an end by the fever, against the ravages of which his life had been expended." This disease was fostered by over crowding, ill ventilation, and filth.

Scurvy formerly produced a very great mortality, especially among sea-faring men. In Admiral Anson's fleet in 1742, out of 961 men, 626 died in nine months, or nearly two out of every three, and this was no solitary case. Captain Cook, on the other hand, conducted an expedition round the world, consisting of 118 men, and although absent over three years, only lost one life. He was practically the first to demonstrate the potency of fresh vegetables in preventing scurvy

The facts respecting small-pox hardly require to be given in great detail. But few now living, however, have any adequate conception of the enormous amount of suffering and death it occasioned before the introduction of vaccination. In the Danish dominions, for instance, from 1762-92, 9,728 died from small-pox. About the year 1802 vaccination was first introduced, and soon was generally though not universally adopted, with the result that only 58 died of small-pox between 1802 and 1810; that is, 7 per annum as against 320. At the last date, vaccination was made compulsory by command of the king, and the inoculation of small-pox prohibited, with the result that, from 1810-19 not a single case of small-pox occurred.

It is cause for congratulation that so much has already been done in the prevention of disease; as may be inferred from the fact that, while the yearly mortality in London 200 years ago was 80 per 1,000, it only averaged 18·9 in the four years 1887-90; and the death-rate of England and Wales has declined from 22·2 in 1851-60 to 17·8 per 1,000 in 1888.

The reason why more progress has not been made in the prevention of disease is not far to seek. In order to prevent a disease it is necessary to remove its causes. The causes of disease can only be ascertained by a careful investigation of its phenomena; and it is only within the last century that these have been studied to any large extent scientifically. The consequence of such knowledge of morbid processes is not only seen in improved measures of treatment, but is the formulation of rules for preventing their onset. Thus, not only is the number of diseases which are *curable* becoming gradually augmented, but the number *preventible* is even more rapidly on the increase.

Inasmuch as the preservation of health involves the prevention of disease, Hygiene, the science of health, is sometimes called *Preventive Medicine.* That much still remains to be done is evident on every hand, and has been very clearly stated a few years ago in the calculations of Dr. de Chaumont. He showed that, while the

mortality in this country was annually 22 per 1,000, or about 1 in 45, and in certain places and at certain times of the year 40 per 1,000, by the application of the laws of health it might at once be reduced to 15 per 1,000, and in time to a still smaller number. This implies that at least one-third of the deaths, and a proportionate amount of the sickness, in this country are due to preventible causes. Reckoning the population of Great Britain as 34 millions, it follows that the deaths are three-quarters of a million per year, of which a quarter of a million might have been prevented.

Allowing 20 cases of sickness to every case of death, it follows that nearly half the population is ill at least once a year; but it is probable that many more than 20 are ill for every one who dies. If we allow 30 to 1 as the proportion, then two-thirds of the population, or 22½ millions people, are ill every year. Now, if a third of the cases of illness, like those of death, are preventible, one may possibly obtain from these data some idea of the suffering, loss of time and money, and many other troubles and inconveniences which result from illnesses that need never have occurred.

It has been estimated, by a very low calculation, that at least £20,000,000 are lost every year in consequence of these diseases, which the science of Hygiene teaches us how to avoid.

Typhoid fever alone kills 5,000 people every year in England and Wales; as only about 15 per cent. of those attacked die, there must be at least 33,000 cases every year, and it is probable that the number is considerably greater.

Diphtheria, again, kills over 4,000 per annum, and diarrhœa 20,000. Typhoid fever and diphtheria need never occur, and will doubtless be stamped out when our sanitary arrangements become perfect; while diarrhœa is generally due to preventible conditions.

Impure air, impure water, dampness of the atmosphere or soil, ill-adapted clothing, food deficient or excessive in quantity or bad in quality, uncleanliness, and many other conditions, are important causes of disease, and will have to be studied in detail.

The knowledge of the causes of disease is half the battle; when once a disease is traced to its source, as a rule, the agency which produces it can be avoided. Unfortunately, in some cases, men cannot afford to give up an unhealthy occupation, and are obliged to work in ill-ventilated warehouses, and in other ways to contravene the laws of health. We shall find, however, that in most cases by personal care evil results may be prevented, or, at all events, materially diminished.

The subject of Hygiene naturally divides itself into two parts—the health of the individual, and that of the community, or—*Personal* and *Public Hygiene.*

The former treats of the influence of habits, cleanliness, exercise, clothing, and food on health; while the latter is concerned with the interests of the community at large, as affected by a pure supply of air and water, the removal of all excreta, the condition of the soil, etc. It is obvious, however, that these two divisions are not mutually exclusive. What is important to the health of the community, is equally so to each individual member of it. The purity of air and water, for instance, is of immense importance both personally and collectively.

It will be convenient to study first the three main factors in relation to health—food, water, and air—subsequently considering other matters of importance to health, as detailed in the table of contents.

CHAPTER II.

FOOD.

The Objects of Food.—Classification of Foods.—Nitrogenous Foods.—Fats.—Amyloids.—Salts.—Water.

Physiological Considerations.—All substances are foods which, after undergoing preparatory changes in the digestive organs (rendering them capable of absorption into the circulation,) serve to renew the organs of the body, and maintain their functions. Foods may either be *tissue producers* or *force producers*, the first

class renewing the composition of the organs of the body, and the second class supplying the combustible material, the oxidation of which is the source of the forces manifested in the body. The two main manifestations of force in the body are heat and mechanical motion, and these two forms of force are to a large extent interchangeable.

All foods come under one of these heads: they are either tissue or force producers. They may be both, and in many cases are so. Thus, all nitrogenous foods (as meat, legumens, etc.) help to form the nitrogenous tissues of the body, or, if they be in excess, become split up into fats and urea, and so form a source of heat to the body. Similarly fats may, after assimilation, enter into the composition of the various tissues containing fat (of which the brain is the most important), or they may supply an immediate source of heat. Saccharine and starchy foods may also possibly lead to the formation of fat, as well as constitute an immediate source of heat; though this is a disputed point. In this way, nearly all foods may be either tissue or force producers, as the system requires. Commonly they are first worked up into the tissues of the body, and then serve as sources of heat and force.

There are certain foods which do not directly serve as tissue or heat producers, but which are useful in aiding the assimilation of food. Such are the various condiments which may be classed as adjuncts to food. Salt is so necessary to the assimilation of food and to the composition of the various tissues, that it may be ranked as an important food. Water, again, though already oxidised, and so not an immediate source of force, is absolutely necessary to the assimilation of food, to the interchange between the various tissues and the blood, and to the elimination of effete products.

Classification of Foods.—Inasmuch as milk supplies all the food necessary for health and growth during the first year of life, we may expect it will afford us some guidance as to the necessary constituents of a diet for the adult, although, the conditions of life being altered in the latter, we can hardly expect

the same proportions of the different materials to hold good. It can scarcely be expected that the same proportions should hold good, as in the infant rapid growth and building up of new tissues and organs are going on, involving a larger proportional amount of nitrogenous food than in the adult.

The following is the average composition of 100 parts of

	HUMAN MILK.	COW'S MILK.
Casein	3·92	4·28
Albumin	——	·50
Fat	2·66	3·50
Sugar	4·36	4·00
Salts	·14	·72
Total Solids	11·08	13·00
Water	88·92	87·00

It is evident, from this analysis of milk, that our food must contain (at least) representatives of all the above divisions, and this is found to be actually the case. We have, therefore :—

1. **Nitrogenous Foods.**
2. **Hydrocarbons or Fats.**
3. **Carbohydrates or Amyloids.**
4. **Salts.**
5. **Water.**

Condiments and stimulants (tea, coffee, alcohol) are not foods in the strict sense of the word, and will be discussed in a later chapter.

Nitrogenous Foods include albumin, casein, gluten, legumen, fibrin, and gelatin. They all agree in consisting of a complex molecule containing many atoms of carbon, hydrogen, oxygen, and nitrogen, with the addition of smaller quantities of sulphur, and in some cases phosphorus. The nitrogenous substances used as food may be divided into *two* groups, one containing gelatin or

glutin, and the other numerous bodies which receive the common name of proteids or albuminoids.

The per-centage composition of gelatin is :—

CARBON.	HYDROGEN.	NITROGEN.	OXYGEN.
50·0	6·6	18·3	25·1

The per-centage composition of all proteids lies within the following limits :—

CARBON.	HYDROGEN.	NITROGEN.	OXYGEN.	SULPHUR.
52·7 to 54·5	6·9 to 7·3	15·4 to 16·5	20·9 to 23·5	0·8 to 1·6

Proteids also contain a small amount of phosphorus, chiefly as phosphate of lime, but also in minute quantity in their essential structure. The chief proteids used as foods are :—1. *Serum-albumin*, forming a large part of the blood and all the tissues of animals. 2. *Egg-albumin*, which differs from the last in being precipitable by ether. 3. *Plant-albumin*. 4. *Myosin*, the chief constituent of muscle. 5. *Casein*, which contains less sulphur than albumin, and no phosphorus. This deficiency of phosphorus is compensated for by the fact that a considerable amount of phosphates is carried down with casein from the whey of milk, when cheese is being made. The most striking characteristic of casein is its property of being coagulated by gastric juice before digestion occurs. 6. *Legumin*, or plant-casein, contained in the seeds of leguminous plants. 7. *Fibrin*, the filamentous part of a blood clot. 8. *Plant-fibrin*, an insoluble substance, occurring especially in the seeds of cereal grasses. A tenacious mass of *gluten* is obtained from wheat-flour by washing away the starch granules and soluble albumin by water. By boiling the gluten with dilute alcohol, the vegetable gelatin or glutin is removed, and after the fats are extracted by ether, fibrin is left. Gluten must not be confounded with glutin (gelatin). Gluten is a mixture of fibrin and glutin or gelatin. 9. *Peptones* are

formed from any of the proteids by the action of the gastric and pancreatic juices. They differ from the other proteids, in not being coagulated by heat, and in being diffusible through animal membranes; hence they easily obtain entrance into the circulation.

By nitrogenous foods (and especially proteids), the fundamental tissues of the body are constructed and repaired. Some heat is also produced by their oxidation, and this oxidation may occur (1) as part of the constant molecular changes and renewal going on in the tissues, or (2) from direct oxidation of nitrogenous food. It is found that when nitrogenous food is given alone to dogs, all the oxidation processes are greatly increased, and there can be no doubt that in all cases nitrogenous food determines, to a large extent, the oxidation of non-nitrogenous food, and so is favourable to all vital action. The action of nitrogenous food in thus increasing oxidation may make it, when in *relative excess*, a tissue waster. Banting's cure for corpulence is founded on this principle.

Hydrocarbons, or fats, consist of the three elements, carbon, hydrogen, and oxygen, the amount of oxygen present not being sufficient to oxidise completely either the hydrogen or the carbon. Thus the molecule of stearin, which may be taken as a typical fat, has the formula $C_3H_5\ (C_{18}H_{35}O_2)_3$.

In respect to their comparatively unoxidised condition fats compare favourably with starch and sugar, $C_6H_{10}O_5$ and $C_6H_{12}O_6$ respectively. It is evident that in starch the $H_{10}O_5 = 5H_2O$, and that in sugar $H_{12}O_6 = 6H_2O$, so that in both cases only carbon remains uncombined with oxygen. Dried fats produce by their oxidation $2\frac{1}{2}$ times as much heat as a corresponding amount of sugar or starch; but the relative advantage of fat is not so great as would appear from this comparison, inasmuch as metabolism within the body is not identical with oxidation, though similar (in this chapter the term *oxidation* is retained).

The fat obtained from food is not simply deposited in the body as such, to form a store of combustible matter, and to fill up the interstices between the different tissues. If this were so, we

should have the kind of fat deposited varying with the food, which is not usually the case. The fat of the body is probably not formed directly from food, but as the result of the oxidation of nitrogenous tissues and foods when this oxidation is incomplete. In the formation of milk this can be distinctly proved : the fat cells are formed from the protoplasm of the cells of the mammary gland ; and as a matter of experience it is found that the quantity of fat in milk is largely and directly increased by albuminoid food, but is actually diminished by fatty food. This is partly owing to the fact that albuminoids increase oxidation changes in the body.

In the "ripening" of a cheese there is apparently a similar conversion of proteids into fat, but it has been shown that the increased per-centage of fat is only apparent, being due to the loss of water.

Possibly amylaceous food may be a source of fat, as well as nitrogenous and fatty food. This appears to be the case in the well known instance of the Strasburg goose, which is kept penned up in a warm room, and fed entirely on barley-meal, in order to produce an enormous fatty liver for the delicacy termed *pâté de foie gras.* But a more likely explanation is that the large accumulation of fat in the liver is due to the warmth and inaction of the goose diminishing oxidation, and producing a fatty degeneration of the nitrogenous material of the liver.

Fats and amyloids, unlike proteids, do not excite oxidation-changes in the system, and so, if in excess of the requirements of the system, can be stored up with comparative ease. Quiet and warmth diminishing oxidation, conduce to the accumulation of fat in animals being fed for the market ; and the same applies to human beings.

Carbohydrates or amyloids include the various starchy and saccharine foods. They are inferior to fats in nutritive power, but, being very digestible, are in much greater favour. In the process of digestion, starch is converted into grape sugar, and starch and sugar are practically equal in nutritive power. We

have already named the possible production of fat from amyloids in the system. It is doubtful if this occurs, or whether the amyloid acts as an easy combustible matter, saving the reserve fat in the tissues.

Even when amyloids are entirely absent from the food, they may be produced in the organism by the breaking up of nitrogenous matter. This certainly happens in diabetes, in which the nitrogenous food rapidly becomes converted into sugar and urea.

The deprivation of amyloid food is much better borne than that of fats, because in the latter the hydrogen is not completely oxidized, and because fats aid the assimilation of other food.

Salts, and especially common salt (chloride of sodium), are essential to health. Liebig has said, that for all purposes of nutrition, a diet free from salt is no better than eating stones. Excess of food is found to be much less injurious when salt is freely taken.

Chloride of sodium is necessary for the production of the acid (hydrochloric) of gastric juice, and of the salts of bile; half the weight of the ash of blood consists of it. An adult requires 150 to 200 grains of salt per day; a large part of this is taken in meat, bread, etc.; and it is advisable that what is added should always be thoroughly incorporated with the food, and not left, in the case of children, to choice. Potassium salts form an important part of milk, muscle juice, and the blood corpuscles. They are obtained from bread and fresh vegetables and fruits. Calcium phosphate (bone earth) is essential for the growth of bones, and is very important for the young. The best source for it is milk, in which it is present in considerable quantities.

Liebig's beef extract contains phosphates largely, and so is useful as an addition to soups, and for making gravy for meats like veal, in which phosphates are deficient. Oxide of iron is always present in the ash of blood and muscles, and in smaller quantities in milk. Fish and veal are usually deficient in it. It is estimated that there are only 150 grains of iron in a

man weighing 154 pounds; yet this amount is absolutely essential for health, and if deficient, the individual looks pallid, and is weak and unhealthy. After cremation, the iron in the ashes has been stated to be collected and made into a mourning ring.

Water forms an important article of diet. This is evident from the fact that 80 per cent. of the blood consists of it, and 75 per cent. of the solid tissues; and from the fact that the daily loss of water from the system averages 50 ounces (2½ pints) by the kidneys, 18 ounces by the skin, and 9 ounces by the lungs. Water is not simply received into the system as a liquid. It forms a large proportion of the solid food taken. Thus, 87½ per cent. of milk, 78 per cent. of fish, 72 per cent. of lean meat, 38 per cent. of bread, 13 per cent. of peas, and 92 per cent. of cabbage, consist of water.

Without water the food cannot become dissolved in the alimentary canal, and so gain entrance into the blood. The water thus dissolving the food comes from the blood in the shape of the digestive secretions, and copious drinks during meals only hinder the process. In the blood, water serves to carry nutrient materials to all the tissues; and, at the same time being circulated all over the system, equalises the temperature, favours chemical changes, and lubricates all the tissues. By water again, the effete matters which have been separated by the kidneys are washed out of its tubes.

The **Oxygen** of the air, in a broad sense, forms one of the foods of the system. This will be considered later.

Besides the above classification, foods have also been classified as follows:—

1. *Inorganic food*—oxygen, salts.

2. *Organic foods*	Animal	Nitrogenous.
		Non-nitrogenous.
	Vegetable	Nitrogenous.
		Non-nitrogenous.

Or, as—

1. *Solid foods*	Animal		Nitrogenous. Non-nitrogenous.
	Vegetable		Nitrogenous. Non-nitrogenous.
2. *Liquid foods*	Water. Milk and its products. Tea and similar beverages. Alcoholic beverages.		
3. *Gaseous foods*—Air.			

CHAPTER III.

THE VARIETIES OF FOOD.

Gelatin.—Red and White Meats: Beef, Mutton, Veal, Pork, Birds, Fish.—Eggs.—Milk and its Products.—Animal Fats.—Butter.—Cereals.—Wheat, Oatmeal, Barley, Maize, Rye, Rice.—Legumens.—Potatoes, and other Vegetables.—Fruits.—Starches: Sago, Tapioca, Arrowroot.—Sugars.

Nitrogenous Animal Foods.—These are divided into two groups, the one containing gelatin, and the other all the proteid or albuminoid substances, which are taken in the flesh of various animals, and in milk and eggs.

Gelatin is obtainable from bones, and from connective tissue wherever found. Being easily digested and absorbed, it has been very popular as an invalid's food; but the fact that animals cannot sustain life on it without the addition of other nitrogenous food, proves that its value is very limited. Later experiments tend to show, that although gelatin alone is of little value, yet animals fed on it with an insufficient amount of albuminoid food continue to flourish, when with the latter alone they would rapidly lose strength. It is probable, therefore, that in the liquid condition in the blood gelatin is broken up into urea, carbonic acid, and water, thus forming a source of heat to the body, but that it is not built up into the body-tissues. It is useful for invalids, partly because it forms a bulk, and prevents

the evil tendency to give their food in too concentrated a form; partly because it forms a source of easily oxidised material, and so prevents tissue-waste; and partly because it commonly contains phosphate of lime, derived from the bones forming the source of gelatin.

Gelatin as prepared for the table contains a considerable proportion of water; as little as one per cent. of gelatin in water will cause it to gelatinise on cooling. Isinglass obtained from the floating bladder of the sturgeon is an example of the purest kind of gelatin; glue is an inferior sort, made from bones.

For dietetic purposes it is undesirable to have gelatin in a concentrated state, as it is in that condition less easily permeated by the digestive juices. This explains the comparative indigestibility of the stiff jellies sold by pastry-cooks.

The **Flesh** of various animals is one of the main sources of our nitrogenous and fatty food. Meats may be divided into two kinds, viz., **red meat** and **white meat.** These gradually merge into one another. As common examples of red meats, we have beef, mutton, pork, game, wild fowl, and salmon.

The common fowl and turkey, most fishes, rabbits, crustaceans, and molluscs, are examples of white meat. As a rule white meats are more digestible than red, having more delicate fibres, and containing a smaller proportion of nitrogenous matter.

Flesh consists almost entirely of muscular tissue, of which there are two kinds, striped and unstriped.

The striped is the variety most commonly used as food. Unstriped muscle has a softer texture, but is not so easily masticated as striped, and for this reason may be indigestible. *Tripe* is the best kind of unstriped muscle, and if well cooked forms a cheap and easily digested dish.

The influence of feeding on the quality of meat is becoming better appreciated. In ill-fed or old animals, connective tissue is more abundant, and so the meat is tougher. Well-fed and fattened meat contains for equal weights about 40 per cent. more dry animal

matter than non-fattened meat. Young animals, again, contain more water and fat and a larger proportion of connective tissue than the full-grown, and are consequently not so nourishing.

Meat ought to be eaten either before the onset of *rigor mortis*, or near its end, before putrefaction has commenced. During *rigor mortis* it is denser, and more difficult to digest; and before, it is tougher than after it.

The proportion of fat in meat varies greatly in different individuals of the same species, in different animals, and in different parts of the same animal. The proportion of water diminishes as the fat increases. According to Dr. Ed. Smith, the proportion of fat in fat oxen is $\frac{1}{3}$, in fat sheep $\frac{1}{2}$, in calves $\frac{1}{6}$, lambs $\frac{1}{3}$, and fat pigs $\frac{1}{2}$.

Good meat, whether beef or mutton, ought to have a marbled appearance, a medium colour, neither pale pink nor deep purple; its texture should be firm, and not leave the impress of the finger, its odour slight and pleasant, the juice reddish and acid, the bundles of fibres not coarse, and free from foreign particles imbedded in them; and lastly, it should not be taken from an animal killed near parturition, nor in consequence of any accident or disease.

Beef is, as a rule, more lean than mutton or pork; it has a closer texture, and more nutritive material in a given bulk. It is also fullest of the red-blood juices, and possesses a richer flavour than the two others.

If the nutritive matter from it is required in a liquid condition, little or no heat ought to be applied in the preparation. Liebig's beef extract is said to contain neither albumin nor gelatin, though 7 to 10 per cent. of the latter is sometimes present. It is a valuable stimulant in cases of prostration, and increases the appetite for other foods. Its chief constituents are the various extractives of meat, the most important of which are inosinic acid, kreatin ($C_4H_9N_3O_2$, H_2O), and inosite, or muscle sugar ($C_6H_{12}O_6$, $2H_2O$). One pound of fresh

mutton or beef yields five grains of kreatin; the same weight of fowl yields half as much again.

Mutton is more suitable for people of sedentary occupation than beef. The leg is the best joint, and the shoulder the next best. **Lamb** is more watery than mutton, and less nutritious. Its delicate flavour makes it a favourite, but it is an extravagant form of food.

Veal as ordinarily prepared in this country, is difficult of digestion, its shreddy, juiceless fibres eluding the teeth, and consequently not undergoing proper mastication.

Pork is not so digestible as beef or mutton, partly because of the large proportion of fat, and partly because its fibres are hard and imperfectly masticated. But its digestibility varies greatly with its age, breeding, and proportion of fat.

The **Flesh of Birds** contains very little fat, and that found separate from the meat is rarely nice. Most birds are edible, but fish-eating birds are apt to be nasty. As a rule, the flavour of the male bird is richer than of the female. The chief virtues in poultry are their tenderness, and the large proportion of phosphates they contain. They are deficient in fat and in iron. To compensate for the former, one commonly takes with them melted butter and fat bacon or pork sausages; to compensate for the latter, the addition of Liebig's extract to the gravy is valuable. During the winter months it is difficult to get tender fowls. Young, and consequently tender, birds are known by their large feet and leg-joints. When a bird appears at table with violet-tinged thighs and a thin neck, if possible avoid being helped to the leg. Wild fowls are harder and less digestible than tame. In ducks and geese fat is more abundant, and of a stronger flavour: they are, consequently, not so digestible as fowls.

Fish forms a very important and too much neglected article of diet. It is easily cooked, and usually very digestible; it possesses a larger bulk in proportion to its nutritive quality, and hence is very valuable for those who habitually take an excess of meat

food, which is commonly the case with those leading sedentary lives, and in declining years. As most fishes contain a larger proportion of phosphates than other meats, they form a useful brain food. Generally, white-fleshed fish is more digestible than red-fleshed (such as salmon), the latter usually containing more fat than the former. When the fat is distributed throughout the flesh, as in the salmon, fish is more satisfying than when it is mainly stored up in the liver, as in the cod-fish. According to Payen, the proportion of fat in soles is only 0·248, in whiting 0·383, conger eel 5·021, mackerel 5·758, eels 23·861. The addition of some fatty food, as melted butter, is very advisable to such meats as poultry, rabbits, soles, whiting, plaice, haddock, cod, turbot, and other fishes; whereas sprats, eels, herrings, pilchards, salmon, etc., are more or less rich in fat.

A Hen's Egg usually weighs a little under two ounces. It consists of 70 per cent. of water and 30 per cent. of solid matter. The white of the egg is chiefly albumin, the yolk consists of a very digestible oil, rich in phosphoric acid, each particle of the oil being enveloped in a form of albumin called vitellin. The salts are chiefly contained in the shell. There is no sugar in the egg, the necessity for such oxidisable material being obviated by the heat produced by incubation. Eggs, when kept for some time, lose weight, owing to evaporation through the porous shell; similarly, air entering from without sets up decomposition. In a solution of brine containing an ounce of common salt to half a pint of water, fresh eggs sink, stale ones float; rotten eggs may even float in fresh water. Eggs may be preserved by keeping them in brine, or, better still in lime water, or even by smearing them over with lard or butter, so as to render them non-porous.

Milk has a specific gravity of 1031-34 as estimated by the lactometer, and on allowing it to stand in a long narrow vessel ought to form ten or twelve per cent. of its volume of cream. The per-centage composition of human and cow's milk has already been given. There is some constancy in the amount of solids present in

pure cow's milk, the average being about $12\frac{1}{2}$ to 13 per cent.; by stall-feeding this may be increased. Half a pint of milk supplies as much nitrogenous nutriment as two good-sized eggs, and as three and a half ounces of beef. Milk may be deteriorated by (1) skimming, or (2) the addition of water—the first diminishing the proportion of fats, and the second the total amount of solids. It is probable that not ten per cent. of metropolitan milk is absolutely genuine. It is found that rich milks containing a large proportion of fat are lighter than poor milks, and their specific gravity may actually be raised by skimming; it is evident, therefore, that the lactometer alone is not a safe guide in the detection of impoverished milk. If the per-centage of cream be observed as well as the specific gravity of the milk, a reliable indication is obtained. The only complete method of ascertaining the condition of milk is a chemical analysis of the amount and character of its solids.

Condensed Milk is milk deprived of a large part of its water. It represents three times its volume of fresh milk. It has one-third its weight of extraneous sugar added to it, and on account of this it tends in children to produce fatness, and a distaste for simple food; also, it is probable that in children fed on it alone ossification is retarded, and resistance to illness is diminished. The only dietetic advantages it possesses over ordinary cow's milk are its freedom from disease germs and easier digestibility.

Cheese is prepared by coagulating milk by "rennet," the mucous membrane of the fourth stomach of the calf, salted and dried before using. By this means the casein is precipitated, carrying down with it the cream, and a large proportion of the salts of milk. The whey, containing the sugar, soluble albumin, and remaining salts, is separated by straining, while the mixed curd and fat are pressed in moulds. Cheese thus consists of casein, fat in varying proportions, water and salts, especially phosphate of lime. It is coloured with annatto, a vegetable colouring matter. When new, cheese is tough; when old, its oils tend to become rancid; the best age is from nine to twenty months. It is probable that cheese in small amount helps the digestion of other foods, though itself a

highly concentrated and comparatively indigestible food. When toasted it is proverbially indigestible.

There are many different kinds of cheese. The following classification gives the most important varieties :—

(1) Cream cheese is the new curd only slightly pressed, and is more digestible than ordinary cheese.

(2) Next to these are cheeses made with whole milk rich in cream, such as Stilton, Gorgonzola, Cheshire, and Cheddar.

(3) Cheeses made of poor or partially skimmed milk, such as Shropshire, Single Gloucester, and Gruyère.

(4) Cheeses made of skimmed milk, such as Suffolk, Parmesan, and Dutch.

American cheeses may belong to any of these classes, they are generally good and pure.

Non-Nitrogenous Animal Foods.—These are all fats, and the most important are the various meat fats and butter. They possess a higher food value than amyloids, and are more rapidly transformed in the body. The composition of the various fats differs somewhat; they usually contain varying proportions of olein, palmitin, and stearin, which are compounds of glycerine with the radicle of a fatty acid (stearin = $C_3H_5(C_{18}H_{35}O_2)_3$). Thus mutton suet consists of stearin, olein, and palmitin, with a preponderance of stearin. Beef suet contains less stearin and more olein than mutton suet. The more olein a fat contains the less solid it is. Olive oil is composed almost entirely of olein. Palmitin, which melts sooner than stearin, is the chief solid constituent of butter, while olein is its chief liquid constituent. Butter is specially distinguished by containing about 5 per cent. of "volatile fatty acids," such as butyric, caproic, etc., combined with glycerine. The presence and amount of these compounds is an important test for the freedom of butter from adulterating fats. The lard of commerce is generally pure, but is sometimes adulterated with water and salt, which become apparent on melting it.

Cod-liver oil is perhaps the most digestible animal fat known. The best cod-liver oil is frozen at a low temperature, by which

means the stearin is frozen out, and nearly pure olein is left. Traces of iodine have been found in it, and more commonly a small amount of bile, which probably increases its digestibility.

The temperature at which a fat becomes hard is a fair guide to its digestibility. Thus we know that beef, and still more, mutton fat, would become solid, under conditions in which bacon dripping is still soft. Where digestion is weak, there may be an instinctive loathing of fat meat; this ought not to be encouraged in children, and some other fat should always be substituted. Thus the addition of butter to the potatoes makes up the deficiency.

Butter forms $3\frac{1}{2}$ to $4\frac{1}{2}$ per cent. of cow's milk. It is separated from milk by churning, the oil particles being deprived by this means of their albuminous coats. The more completely the butter-milk is separated the longer the butter keeps. It can be kept longer if salt is added, or in hot weather by keeping it under frequently-changed water. Rancidity indicates the decomposition of traces of the fat of butter into its fatty acid and glycerine.

The odour and flavour of butter are not due to olein and palmitin, the two chief constituents, but to a smaller quantity of butyrin, a fat of a much lower series. Ordinary butter contains a considerable proportion of water, and the presence of about 8 per cent. renders it more palatable; if it is over 15 per cent., the butter is considered adulterated. Another fraud is the addition of an excessive amount of salt.

Margarine is prepared from beef-fat by melting, the stearin separating out while the olein and margarine are left behind. It forms a wholesome and cheap food, preferable to bad butter, but is often sold fraudulently as butter, at the price of the latter. When mixed with a small proportion of butter, its recognition by smell, etc., is almost impossible, but on careful chemical analysis, it is found to have a higher melting point and a lower specific gravity than butter, and a much smaller percentage of soluble fatty acids than the latter.

Cream contains about 30 per cent. of butter fat, Cheshire cheese 25 per cent., and skim milk cheese 7 per cent.

Butter-milk, which contains all the constituents of milk, except the fat, is a highly nutritious and easily digested drink, and one which is undeservedly neglected. It is especially valuable for invalids who cannot digest fats, and for children who are wasting.

Cereal Foods.—Gluten is peculiar to plants, and is chiefly found in plants belonging to the great family of grasses. Gluten is to bread, what casein is to milk, and myosin to flesh. If one takes a piece of dough made from wheat flour, and holds it under a stream of water from the tap, a large part of it is washed away, while a sticky adherent mass is left behind. This is gluten, and it is its tenacity which enables bread to be made. If the fluid with which the dough was washed is collected, it will be found to contain a large quantity of starch, a small amount of sugar, of albumin, and certain salts. All cereals possess these constituents in various proportions. The cereal which is most universally useful is wheat; from its fruit is obtained flour, the character of which varies according as the husk is removed before grinding or not. A hot summer diminishes the water in wheat and increases its gluten.

Good **wheat flour** ought to be white, not gritty or lumpy, not acid or musty, forming a coherent stringy dough, and possessing at least 8 per cent. of gluten. Examined microscopically, it should show the absence of any fungi, or vibriones, or acarus farinæ, or of foreign starches, such as barley, maize, rice, potato (known by the different shape of their starch granules). Alum is occasionally added to flour; more rarely sulphate of copper or gypsum. The chief object of the addition of both alum and sulphate of copper is to enable the baker to make a white and porous bread from damaged wheat flour. It is not uncommon for rice, potato, or pea flour to be added. 100 pounds of good flour ought to yield 130 pounds of bread.

Bread made from good seconds flour is as nutritious as pure white bread. This is especially important for the poor, who live largely on bread.

Brown bread is valuable to most persons as an occasional change

of diet; the bran is rich in fat as well as phosphates. It acts as a mechanical irritant, ill borne by delicate stomachs, but very useful where a tendency to constipation exists.

The harder wheats, such as Sicilian wheat, contain a large percentage of gluten; and from them *macaroni* and *vermicelli* are obtained, which are nearly pure gluten. They are very nutritious and useful foods.

Oatmeal, obtained from the common oat, contains very little gluten, and so cannot be made into vesiculated bread. It contains a large proportion of other nitrogenous material and of fat. As porridge and oatmeal cake it is very popular in the north, and forms a very nutritious diet. The husk ought to be carefully removed from the meal intended for human food, as, although very nitrogenous, it acts as a mechanical irritant.

Barley contains very little gluten, its nitrogenous matter being chiefly albumin and casein; on this account, like oatmeal, it does not admit of being made easily into ordinary bread, but requires the addition of wheat flour. It is not so nourishing, but is cheaper than wheat. Added in small quantity to wheat flour, it keeps the bread moist and improves its flavour.

Malt is barley which has been made to germinate by heat and moisture and then dried. During this process, a nitrogenous ferment called "diastase" is formed, which possesses the power, in the presence of water, of changing starch into dextrine and sugar. *Extract of malt*, containing diastase in an active condition, is extremely useful in cases of impaired digestion and deficient assimilation of food.

Rye is rarely used in this country for making bread. In Germany it is known as "black bread," but its colour and acid taste make it disagreeable, and it is laxative in its action. It is also liable to be attacked by a parasitic fungus (the ergot of rye), and if eaten in this condition may produce severe symptoms.

Maize, or Indian Corn, is very deficient in gluten, and so not suitable for making vesiculated bread. Like oatmeal, it is made

into cakes, called in America "Johnny cake." It contains much fatty matter, and is largely used for fattening poultry and other animals. Oswego flour and corn flour are maize flour deprived, by a weak solution of soda, of its albuminoids and unpleasant flavour.

Rice contains less gluten or nitrogenous material than any other cereal, and does not admit of being made into bread alone. It is not so nutritious as the other cereals, its chief value as a food depending on the large amount of starch it contains.

The best kinds of rice coming to this country are known as Patna and Carolina rice. Carolina rice becomes more mucilaginous when cooked than Indian rice, and is more nutritious.

Leguminous Foods.—The chief seeds belonging to this group are peas, beans, and lentils. They contain a smaller proportion of starch, and a larger proportion of nitrogenous material than cereals. The nitrogenous material exists chiefly as legumin, which has been called vegetable casein, and from it the Chinese make a kind of cheese. Although leguminous seeds contain more nutritive material in a given weight than cereals, dietetically they are inferior, owing to the fact that they are less digestible, often causing flatulence and other dyspeptic symptoms. Cereals, again, are more palatable than leguminous seeds, and are more prolific, and consequently cheaper. In the absence of animal food, legumens form a useful substitute. They are advantageously diluted with oily substances, or with rice. The farm-labourer's dish of broad beans and fat bacon is founded on strict physiological principles. A mixture of lentil and barley flour is sold under the name of Revalenta Arabica. Green peas, French beans, and scarlet runners are much more easily digested than are dried peas or beans.

Amylaceous Foods.—Amylaceous, starchy, or amyloid substances are contained in many of the preceding foods; but there are some other foods which consist almost entirely of starch. The chief of these are sago, tapioca, and arrowroot.

Sago is obtained from the pith of the stems of various species of palm; a single tree may yield several hundred pounds. Alone it is

easy of digestion, and somewhat nutritive. Boiled with milk it forms a light, nutritious, and non-irritating food. Fictitious sagos are frequently sold, made from potato starch.

Tapioca and **Cassava** are derived from the tubers of more than one species of the poisonous family, Euphorbiaceæ. The juices are removed, and the poisonous principle destroyed by heat. Tapioca only differs from cassava in being a purer form of starch; the latter is more nutritious, and among the Indians takes the place of bread. Tapioca is more soluble than sago, and so requires less time for cooking.

Arrowroot is obtained from the tubers of Maranta Arundinacea. It contains 80–90 per cent. of starch, and is therefore not highly nutritious, though it is easily digested and non-irritating.

Tous-les-mois is a form of starch obtained from the tubers of a West Indian plant, the Canna edulis. **Salep** is obtained from the roots of several species of orchids.

Starch is contained in very many vegetable foods. Its proportion in 100 parts is shown in the following list. In barley flour it forms 69·4 per cent.; wheat flour, 66·3; wheat bread, 47·4; oatmeal 58·4; Indian corn meal, 64·7; rye meal, 69·5; rice, 79·1; peas, 55·4; potatoes, 18·8; parsnips, 9·6; carrots, 8·4; turnips, 5·1.

The small proportion of starch present in potatoes is due to the large amount of water entering into their composition, and not to the presence in more than minute quantities of any other constituent.

Other Vegetable Foods.—**Green Vegetables** contain comparatively little nutriment, but form valuable additions to other foods. Cellulose, which forms their main constituent, is a useful stimulant to the alimentary canal; and the salts they contain possess valuable anti-scorbutic properties. The addition of a bulk of comparatively innutritious food to other more digestible foods is very important; every kind of natural food is bulky, thus giving the alimentary canal more mass to act upon. Concentrated nourishment can only be digested in limited quantity, and is very apt to produce

digestive disorder. Cabbage contains 92 per cent. of water, and $2\frac{1}{2}$ per cent. nitrogenous matter. Carrots contain 6 per cent. and turnips 2 per cent. of nitrogenous matter; parsnips are intermediate between these.

Rhubarb and sorrel contain oxalates and tartrates of potash and lime, to which they owe their tartness. Spinach is cooling and laxative, like rhubarb, but not tart. Sea-kale, artichoke, and asparagus are all wholesome vegetables. Asparagus is somewhat diuretic, and gives a peculiar, disagreeable odour to the urine. Salads, such as mustard and cress, watercress, endive, and the garden lettuce are very useful as anti-scorbutics. Some of them possess a peculiar pungency due to a volatile oil analogous to that contained in horse-radish.

The **Potato** contains 26 solid parts in 100, of which nearly 20 are starch and $2\frac{1}{2}$ nitrogenous matter. It forms one of our best-appreciated vegetable foods, and, as it possesses valuable anti-scorbutic properties, its universal use is, perhaps, the chief cause of the present rarity of scurvy. Alone, it possesses too small a proportion of nitrogenous material to support life, but the addition of butter milk makes up this deficiency; and these two together form a sufficient diet to maintain life and health for a long time, though so limited a diet would, probably, be ultimately injurious.

The **Onion, Garlic, Leek,** and **Shalot,** all members of the lily family, are chiefly used as condiments. They contain an acrid volatile oil, which gives them a peculiar odour and flavour. By long boiling, this is dissipated (as in the case of the Spanish onion), and the onion is then fairly digestible, as well as nutritious.

Celery possesses a more delicate flavour and odour than the preceding, but even the most tender celery is digested with difficulty; less so, when boiled or stewed, or a constituent of soups.

Only four **Fungi** are, with us, commonly regarded as safe—mush rooms, champignons, morels, and truffles; but there are many others which, if their characters were but known, form nutritious and

delicate foods. The difficulty lies in distinguishing the poisonous from the non-poisonous forms. Dr. Christison says, that a sure test of a poisonous fungus is its astringent styptic taste and disagreeable pungent odour. In any doubtful case it is better to abstain.

Oily Seeds contain a considerable amount of fixed oil, which renders them unfit for persons of weak digestion. The almond, walnut, hazel-nut, and cocoa-nut are common examples. The sweet almond, when eaten unbleached, occasionally produces nettle-rash, and its solid texture and large proportion of fixed oil render it difficult of digestion. The bitter almond contains oil of bitter almonds and glucose; also a peculiar principle called amygdalin, which, on the addition of water or saliva, forms prussic acid. The *chestnut* is not an oily seed, but possesses considerable nutritive matter. It is extensively used as a food in Italy and some other countries. In the uncooked condition it is very difficult of digestion.

Fruits are chiefly used as adjuncts to other foods; but the vegetable salts, and the cellulose and sugar which they contain, make them very valuable. **Cucurbitaceous** fruits are used as vegetables rather than as fruits. Vegetable marrow is wholesome and agreeable, but not very nutritive. Cucumber is, on the contrary, a somewhat dangerous food, being a fertile source of indigestion and diarrhœa. The more rapidly grown, and the fresher it is eaten, the more digestible it is.

Stone-fruits or drupes, such as the peach, nectarine, plum, cherry, are rather luxuries than foods, like many other fruits. Before ripening they are unfit for food; when ripening is complete, the acids and astringent matter largely disappear. The *date* contains chiefly sugar, and forms an important food in the East.

Pomaceous Fruits, as the apple, pear, and quince, are more digestible when cooked; and, speaking generally, all fruit not perfectly ripe should be cooked before eating. The presence of vegetable acids in fruit soon converts the sucrose of cane sugar

into dextrose, a less sweet variety of sugar. It is therefore more economical to sweeten after than before cooking.

The chief **Berries** are the grape, currant, gooseberry, cranberry, and elderberry. The grape is the most important, and 1,500 varieties of it have been described. Its juice contains a large amount of grape sugar (dextrose), and small quantities of glutinous material, bitartrate of potash, tartrate of lime, malic acid, etc.

Besides the above fruits, we have strawberries, mulberries, figs, plantains, melons, etc., which are all refreshing and anti-scorbutic. The orange family furnishes us with the orange, lemon, citron, lime, shaddock, and pomelo, of which the orange is by far the most important, and possesses most valuable refreshing qualities.

Sugar forms a valuable food, equalling starch in this respect. It exists in three chief forms, all of which are converted into glucose before absorption into the blood. The chief sugars formerly known were honey, grape, manna, and fruit sugars. Now we have in addition cane, maple, beet, maize, and palm sugars, all consisting of sucrose.

The common sugar or **sucrose** is obtained from the sugar cane or from the beet. (Sucrose = $C_{12}H_{22}O_{11}$; compare starch = $C_{12}H_{20}O_{10}$).

Grape Sugar (dextrose or glucose) = $C_6H_{12}O_6$, H_2O, can be seen crystallised in dried raisins : it only possesses one-third the sweetening power of sucrose. Starchy food becomes changed into glucose by the action of saliva and pancreatic juice in the alimentary canal. Grapes, cherries, gooseberries, figs, and honey contain lævulose in addition to glucose (glucose = $C_6H_{12}O_6$, H_2O, lævulose = $C_6H_{12}O_6$). Lævulose resembles dextrose except in being uncrystalline, and in its effect on polarised light. Many ripe fruits, such as pineapples, strawberries, peaches, citrons, contain sucrose and lævulose, the latter being not quite so sweet as sucrose.

Lactose ($C_{12}H_{24}O_{12}$), or sugar of milk, forms about 4½ per cent. of milk.

The sweetening power of the varieties of sugar depends on their degree of solubility in water. Sucrose is soluble in one-third of its

weight of cold, and in rather more of hot, water. Dextrose is soluble in its own weight of water; lævulose is more soluble, and therefore sweeter than dextrose. Lactose requires five to six parts of cold, and two of hot, water, and is therefore not so sweet as the other varieties.

CHAPTER IV.

DISEASES ARISING IN CONNECTION WITH FOOD.

Meat from Animals Dying a Natural Death.—Measly Meat.—Trichinosis.—Tuberculous Meat.—Putrid Meat.—Tinned Meats.—Disease from Fish.—Dangers of Unboiled Milk.—Pellagra.—Ergotism.—Starvation.—Scurvy.—Rickets.—Gout.

Disease may arise from the noxious character of some individual article of diet, or from deficiency or excess of some particular food, or of the food as a whole.

Diseases from Unwholesome Food.—I. **Diseased Meat.**—It is said that at least one-fifth of the meat entering the London markets is diseased, and the proportion has been placed by some much higher.

(1) *The flesh of animals dying a natural death* is prohibited from sale, and rightly so, as in some cases it produces serious results; but these do not uniformly occur. Some hold that such meat (where the animals have died from a non-contagious disease) ought to be allowed for sale at a lower price, and thus the temptation to smuggle it into the market as healthy meat would be diminished. *Braxy mutton* (from sheep which have died of splenic apoplexy, a bacillus disease common in Scotland,) is largely eaten in Scotland, after salting and cutting away the most diseased parts, and without evil results; but it rapidly decomposes, and is said sometimes to produce boils, etc. Diseased meat is also dangerous, owing to the *drugs* with which the animals have been dosed before death. There is a case on record, in which tartar emetic, taken by an ox before slaughtering, produced serious effects

on 107 people; one person, who died in consequence, had only eaten half a pound of the meat.

(2) Meat may be unwholesome from *the presence of parasites.* Of these the most common is—

(*a*) The **cysticercus cellulosæ**, which is the undeveloped embryo of the tape-worm; that from the pig becomes the tænia solium, that from the ox tænia mediocanellata. The cysticercus of the pig is the most common; it forms a cyst, about the size of a hemp-seed, commonest on the under surface of the tongue. Occasionally one finds in hams oval holes, and opaque white specks, which are the remains of the cysts converted into calcareous matter. When meat containing the cysticercus alive (as in under-cooked or raw meat) is swallowed, it develops into the tape-worm, which consists of a number of flat segments, each capable of producing the ova of new cysticerci, and a minute head at the narrow end surmounted by hooklets. The boiling temperature effectually kills the cysticercus. Another kind of tape-worm common on the continent, called *bothriocephalus latus*, is derived from the cysticercus of fish.

(*b*) The **trichina spiralis** is not a solid worm like the tænia, but possesses an intestine. In pork it forms a minute white speck, just visible to the naked eye, which forms a nest, and in this one or two coiled up worms can be seen by a magnifying glass in active movement. They are effectually killed by the temperature of boiling water; but no form of drying, salting, or even smoking at a low temperature is sufficient for this purpose. Moreover, boiling or roasting does not suffice to destroy the trichina, unless the joint is completely cooked in its interior. When trichinous pork is swallowed, the eggs develop in the alimentary canal in about a week into complete worms, and in three or four days more each female produces over a hundred young ones. These burrow into every part of the body, producing great irritation and inflammation. In one case after death upwards of 50,000 worms were estimated to exist in a square inch of muscle. Most of the cases of trichinosis have occurred in Germany, from eating imperfectly cooked sausages.

(3) **Tuberculous Meat,** from animals suffering from consumption or other tubercular diseases has been said to produce the same disease in man. As tuberculosis is an infective disease, this might occur with imperfectly cooked meat, and the entire carcase of a tuberculous animal should be condemned as unfit for food.

II.—**Putrid Meat** has often produced diarrhœa and other severe symptoms. Putrid sausages are especially dangerous, and incipient putridity seems to be more dangerous than advanced. Habit may produce toleration of putridity, and game is commonly eaten "high." The Eskimos bury their meat until it is putrid; and among the Zulus, according to the late Bishop Colenso, the synonym for heaven is "maggoty meat."

The meat from over-driven or tortured animals has sometimes been found to be unwholesome. Occasionally severe symptoms have followed the eating of pork, brawn, or potted meats. Possibly the development of ptomaines (cadaveric alkaloids) may account for this.

III.—**Tinned Meats** occasionally produce severe illness, which has been in several cases fatal. It is important to secure a good brand, and to eat the meat as early as possible after the tin is opened. The poisonous symptoms may be due to the rapid decomposition occurring after opening the tins, or to the imperfect exclusion of air before this. Occasionally, also, in the case of pickled meats, poisoning is due to the action of vinegar on the soldering of the tins (lead and zinc poisoning). All tinned meats and fruits are stated by Hehner to contain compounds of tin in solution. These do not seem to be perceptibly injurious, unlike lead salts.

IV.—**Meat injuries from the food eaten before killing.**—Pheasants fed on laurel, hares on rhododendron chrysanthemum, and other animals fed on the lotus, wild cucumber, and wild melon of Australia, have caused dangerous symptoms.

V.—**Fish,** especially some kinds, occasionally produce nettle-rash and other disorders, especially in warm weather. Leprosy has been ascribed to the eating of decomposing fish, but it occurs in countries where a fish diet is impossible.

Shell-fish and crustaceans (as lobster, crab) are very prone to

produce evil results. This may be owing to their foul food or to the development of some peculiar animal poison. In some cases, eating only one or two mussels has produced dangerous symptoms.

VI.—**Milk** has been a common carrier of disease. Cows eating the rhus toxicodendron get the "trembles," and their milk produces serious gastric irritation in young children. The milk of goats fed on wild herbs or spurgeworts has produced severe disorders.

The milk of animals suffering from foot-and-mouth disease, although frequently drunk with impunity, occasionally produces inflammation of the mouth (aphthous ulceration). The milk derived from cows fed on grass from sewage farms is, *per se*, as wholesome as any other, and its butter has no more tendency to become putrid than that derived from any other source.

The great danger in respect to milk is of its becoming mixed with tainted water; or of its absorbing foul odours, or the more dangerous, but possibly less perceptible, emanations from drains or sewers, when exposed in an ill-ventilated room. The absorptive power of milk for any vapour in its neighbourhood, is shewn by exposing it in an atmosphere containing a trace of carbolic acid vapour: the milk speedily tastes of the acid.

In addition to its absorptive power for any vapours present, milk tends to undergo rapid fermentative changes, especially in warm weather, or when tainted by traces of putrefying animal matter. Diarrhœa in children is frequently due to such a condition, or to the rapid decomposition of milk in an imperfectly cleaned bottle. It is a wise precaution always to boil milk in warm weather; and it should never be stored in ill-ventilated larders, or where there is a possibility of the access of sewer-gases; nor ought it to be kept in lead or zinc vessels.

Mr. Ernest Hart, in 1881, gave a tabulated account of seventy-one epidemics, traceable to infected milk. Of these, fifty were epidemics of typhoid fever, fourteen of scarlet fever, and seven of diphtheria; and the number of cases of each of these diseases in

all the various outbreaks, were estimated at 3,500, 800, and 500 respectively.

In regard to typhoid fever, the contamination of the milk was traced in twenty-two out of the fifty epidemics to the use of water "for washing the milk-cans," derived from specifically polluted sources, and doubtless the water was the real source of the disease. In most of the cases of scarlet fever, it was found that either there was scarlet fever in the dairy, or that persons employed in the dairy were in attendance on patients suffering from the disease; but in an outbreak connected with a supply of milk from Hendon, there was strong but not conclusive evidence that a certain eruptive disease of the udders of the cow might cause scarlet fever in man, without infection from a previous case of the disease.

Tubercular disease of the intestines and mesenteric glands may be produced by taking milk derived from tuberculous cows. This was proved in the case of calves, and there are strong reasons for thinking that the same is true for infants. The only safe plan is to boil the milk.

Cheese has occasionally produced violent attacks of illness, although no poison could be detected in it. These effects have been ascribed to copper from the vessels in which the cheese has been made, but this view has been disproved in several instances.

VII.—**Vegetable Food** (especially greens) is indigestible if stale, and all mouldy vegetables are dangerous.

Poisonous symptoms have been produced by the admixture of *darnel* (lolium temulentum) with flour.

The eating of *damaged maize* in Italy is the cause of an endemic skin disease, called *pellagra*, which commonly proves fatal. The damaging of the maize seems to be due to the universal practice of paying the landlord in kind, a tithe of the produce of the farm. This leads to the tenant hiding some of his maize in damp holes, and a fungus or mould develops on it which produces pellagra.

Ergotism is due to the growth on cereals (and most commonly on the rye) of a poisonous fungus, the secale cornutum, which pro-

duces a deep purple deposit on the grain. If bread made from such flour is eaten for prolonged periods, severe symptoms result; in some cases, a dry rotting of the limbs. There have been several epidemics on the continent, due chiefly to eating bad rye bread.

Starvation Diseases.—*Simple Starvation* causes death in a period varying with the previous state of nutrition. Usually death occurs when the body has lost two-fifths of its weight, whether this be after days, months, or years (Chossat). A supply of water prolongs the duration of life, to as much as three times what it would otherwise be. In children, a common symptom of a *diet deficient in nutriment* is diarrhœa; it is nature's rebellion against the starchy foods commonly inflicted on children in place of their natural food—milk. Good nourishment doubles the power of resisting disease; this has been abundantly proved in the experience of the Crimean war and other campaigns. Under-fed children in charity schools are very liable to chronic inflammation of the eyes (ophthalmia).

Scurvy is due to the absence of fresh vegetables. The use of the potato and the orange, as well as of lime juice (the juice of citrus limetta), has led to its nearly complete extinction in this country. In former times, it caused more deaths among seamen than all other causes put together, including the accidents of war.

Rickets is chiefly due to improper feeding in childhood. M. Jules Guérin found that by taking young puppies and pigs (representatives of carnivora and herbivora respectively), removing them from the mother prematurely, and giving the former meat and the latter vegetables (their natural foods in the adult condition), he could produce rickety softening of the bones. The substitution of artificial foods (most of them containing starch) for the natural milk—which deprives the infant of a certain proportion of lime and phosphates, of fatty material, and iron—is probably the chief cause of rickets. The time of weaning ought to be settled by the development of the teeth; the suckling may begin to be diminished when the lower incisor teeth appear between the sixth and seventh months. Before this the child cannot digest starchy food.

Relapsing fever generally follows epidemics of typhus fever, and is greatly favoured, if not caused, by starvation.

Diseases Connected with Over-Feeding.—A fire may go out for want of fuel, or from becoming choked with ashes; and it is the latter state of things which occurs in **Gout** and allied diseases. Weakness is commonly complained of, but this is due to excess of food embarrassing vital action; and abstinence and exercise are required to restore the balance. Excess of nitrogenous food—especially if combined with the use of sweet, or strong, or very acid wines, and beer—is particularly prone to produce gout. In these cases, animal food should only be taken once a day, and vegetable food should be allowed to preponderate.

Obesity is favoured by excess of starchy food and sugar, and by copious drinking of water or other beverages. The plan of curing obesity by restricting oneself almost entirely to meat food is not advisable however, as the system tends to become overloaded with effete nitrogenous matter. **Gall-stones** are favoured by rich foods and excess of sugar; also by alcoholic indulgence. **Dyspepsia** is commonly due to over-loading the stomach at frequent intervals; but, on the other hand, it not infrequently leads to the taking of insufficient food, because of the discomfort produced. The result of this is that a chronic starvation results, with impaired vital powers. Dyspeptic patients should abstain from pastry and from tea and coffee, except in small quantities, and not very hot. Alcohol in any form, as a rule, does harm. Not uncommonly mastication is imperfectly performed, and a good dentist may cure the indigestion which has resisted all other treatment.

CHAPTER V.

DIET.

Influence of Diet on Animals.—Circumstances modifying Diet.—Times for Meals.—Vegetable and Animal Foods.—General Rules as to Diet.—Determination of Diet.—The Naturalist's Theory.—Theory of Income and Outcome.—Examination of Dietaries.—Calculation of Diet.

The importance of a duly proportioned and sufficient dietary is shown by its great influence on health and character. An ill-proportioned or deficient diet is certain to lead to failure of health. The anatomy of an animal may be modified in the course of generations by altered diet, as well as its character; thus, the alimentary canal of the cat has increased in length to adapt it to its omnivorous habits. In the case of the bee we have a still more remarkable instance. If by any accident the queen bee dies or is lost, the working bees (which are sexually undeveloped) select two or three eggs, which they hatch in large cells, and then feed the maggot on a stimulating jelly, different from that supplied to the other maggots, thus producing a queen bee.

In making the railway from Paris to Rouen, it was found that two English were equal to three French navvies; on examining for the cause it was found that the former were fed on large quantities of meat, while the latter ate chiefly soup and lentils. The diet of the Frenchmen was altered to the English standard, with the result that the inequality in work soon disappeared.

The food of mankind varies naturally with—

I.—*Climate.* A cold climate leads to increased oxidation, and consequently a large amount of fatty matter can be eaten without producing nausea. Witness the difference between a Laplander's and a Hindoo's diet.

The *season* of the year has likewise some influence. Vital processes are more active in spring than autumn, and more food is consequently required in the former season.

II.—*Occupation.* Although muscular exercise is not associated with an immediate increase of elimination of urea, yet as a matter of experience more nitrogenous food is required and can be oxidised by hard workers than by idlers. The trappers on the North American prairies can live for weeks together on meat alone, accompanied by copious draughts of tea. They are constantly in the open air, undergoing fatiguing exercise, in a dry and rare atmosphere.

III.—*Sex.* As a rule, women require about one-tenth less food than men, but probably this rule hardly holds good in the case of women engaged in laborious work.

IV.—*Age.* Infants require only milk, and the less they have of any other food before a year old the better. Children under eight require chiefly milk and farinaceous food ; at ten, half as much as for a woman is required. It is important to remember that vital processes are more active in early life, and that food is required not only to carry on the functions of the body, but also to furnish the materials for growth. Young men up to twenty-five engaged in laborious work require much more food than older men engaged in the same work.

After the age of thirty-five or forty, the tendency is to take too much food. All the tissues of the body are established, and excess of food (especially nitrogenous food) is liable to produce tissue degeneration by loading the system with partially oxidised matter, and may lead to gouty diseases. It is much safer to take too little than too much food after this period.

Times for Eating.—The best arrangement seems to be to have three meals, each fairly nutritious, and containing all the constituents required. The Romans only had two meals daily, prandium and cœna. This is common among the French at present, but it tends to lead to overloading the digestive organs at one period, while starving them at another.

An ordinary full meal has usually passed from the stomach in four hours. Fresh food ought never to be introduced before this period; it is advisable to allow an interval of five hours between meals for the healthy, so as to give time for the digestive organs to rest.

and for the absorption of food. The practice of taking tea with the chief meal, or a "meat tea," is bad. Tea is better taken an hour or two after food, and ought not to be made a meal of.

Regularity in the times of taking meals is important, as the digestive organs acquire habits like other parts of the body. Work ought not, if possible, to be resumed immediately after meals, nor active exercise of any kind. These tend to abstract blood from the digestive organs, and so diminish the efficiency of digestion.

Vegetable and Animal Foods.—The fact that the food we require can be obtained from the vegetable world, has led to the proposition that vegetable food should be taken alone. It is urged in favour of this plan, that a large amount of suffering to animals would be prevented. Also that animal food is not so economical as vegetable, land being more economically employed in producing corn than in feeding cattle. Thirdly, there is the indubitable fact that health can be maintained for prolonged periods on vegetable food (including nuts, cereals, fruits, etc.)

On the other hand, the chief objections to a purely vegetable diet are that the undigested refuse is greater than with an equal quantity of animal food; that a longer time and more exertion are required in digesting the most nutritious vegetable foods, such as legumens, while other vegetable foods do not contain a sufficient proportion of nitrogenous material. Also, if one lived entirely on vegetable food, a greater bulk would be required, and owing to the fact that such food is less easily absorbed, satisfaction to the appetite would not so soon be produced. Animal food has a great advantage as regards convenience. Man is not an eating machine; he requires food which is easily converted into the body substance, and this is supplied by the flesh of animals, milk, and eggs, with a due proportion of non-nitrogenous food; sheep and oxen work up indigestible vegetable materials into easily assimilable mutton and beef.

There is no doubt, however, that under the ordinary conditions of town life, there is considerable danger of indulging in an excess of nitrogenous food, and vegetarians will therefore do good by

shewing that meat is not absolutely necessary, and can often with advantage be largely replaced by vegetable food.

If we include milk, cheese, and eggs in the vegetarian diet, the objections to it in a large measure disappear; and it would be well if it were much more widely known, especially among the poor, that on these, together with vegetables, health can be maintained with the addition of little or no meat.

The Determination of Diet.—The first principle in making a dietary is that it **must be mixed** containing all the necessary constituents, proteids, hydro-carbons, carbo-hydrates, water, and salts. No one of these alone will support life for any considerable period. Carbo-hydrates (sugar and starch) can be most easily dispensed with; fats, on the other hand, are essential for the maintenance of health.

The next point is to ascertain **the proportion** in which these different foods are required. *Salts* are commonly taken with other foods, common salt being the only one taken alone. About 150 to 200 grains of salt are required by an adult per day. The amount of *water* required varies with the season of the year, the amount of exercise and perspiration, and other factors. As a rule, not more than two pints of water are required per day, and still less if fruit is freely taken. We may therefore confine our attention to the carbonaceous and nitrogenous foods, and try to ascertain the amount of each of these required. This question has been approached from three standpoints:—

1st.—There is what we may call the *Naturalist's Theory*. This assumes that not only does milk contain all the necessary constituents for the maintenance of life, but in the proper proportion for the adult. It is evident, however, that although the milk of various animals is very similar, yet that their habits in adult life vary greatly, and their diet varies similarly. And it is found that nitrogenous matter exists in milk in a preponderant proportion over the fat and sugar, according to the estimate of the requirements of the system, as ascertained by the other methods. This is in accordance with what would be expected, when it is remem-

bered that in early life the tissues have to be built up, while in adult life they have merely to be kept in repair.

2nd.—*The Theory of Income and Outcome.*—The excreta represent the oxidised condition of the food taken into the body. If, therefore, we estimate the amount of carbonic acid eliminated from the lungs and skin, and the amount of urea and uric acid from the kidneys by the urine, we can easily calculate the amount of carbon in the carbonic acid, and of nitrogen and carbon in the urea and uric acid. It is convenient to confine the calculation to carbon and nitrogen, for, although hydrogen is contained in carbonaceous and proteid foods, and is eliminated as water, it is also taken as water for mechanical purposes; and, consequently, the eliminated water does not represent simply oxidised hydrogen. The number of grains of carbon and nitrogen eliminated being ascertained by the above method, if we know the per-centage composition of the various foods, it is easy to calculate the amount of each required, in order to supply the necessary carbon and nitrogen. Some addition must be made to the amount of food required, as thus calculated, for the fæces contain a certain amount of undigested matter, and nearly every food is but partially digestible. A margin must, therefore, be allowed.

According to Dr. E. Smith the average amount of daily losses during idleness are—for an

	GRAINS OF CARBON.	GRAINS OF NITROGEN.
Adult man	4,300	200
Adult woman	3,900	180
Average adult	4,100	190

These amounts are represented by about 22 ozs. of carbonaceous food, and 3 ozs. of nitrogenous food.

3rd.—*Result of Examination of Dietaries.*—It is found that the results obtained by examination of the food taken by men under

various conditions strikingly agree with those obtained from an estimate of the excretions. Dr. Letheby has summarised these results in the following table.

Daily Requirements of the Body (Letheby).

	NITROGENOUS FOOD.	CARBONACEOUS FOOD.	CARBON.	NITROGEN.
During idleness, as determined—	ozs.	ozs.	grs.	grs.
By dietaries... ...	2·67	19·61 =	3,816	180
By excretions ...	2·78	21·60 =	4,199	187
Average ...	2·73	20·60 =	4,005	184
Routine work, as determined—				
By dietaries... ...	4·56	29·24 =	5,688	307
By excretions ...	4·39	23·63 =	4,694	296
Average ...	4·48	26·44 =	5,191	302

Dr. Lyon Playfair found as the result of elaborate analysis the amount of food necessary for—

	NITROGENOUS.	CARBONACEOUS.
Subsistence only	2·0 ozs.	13·3 ozs.
Quietude	2·5 ,,	14·5 ,,
Moderate exercise	4·2 ,,	23·2 ,,
Active work	5·5 ,,	26·3 ,,
Hard work	6·5 ,,	26·3 ,,

Thus, under the three first conditions of life, the proportion of nitrogenous to carbonaceous food was one to six; for active work, one to five; for hard work, one to four. The proportion one to five of nitrogen is ample for persons having moderate exercise. Speaking generally, the amount of nitrogen required is 300 grs.;

of carbon, 4,800 grs., or a proportion of one to sixteen. This, at first sight, looks as though Dr. Playfair's table were incorrect; but the discrepancy disappears when we remember that nitrogenous food contains a large proportion of carbon as well as nitrogen.

It is found, in accordance with the above results, that an average healthy male adult, of average weight and height, and performing a moderate amount of work, requires $4\frac{1}{2}$ ozs. of nitrogenous food, 3 of fats, $14\frac{1}{4}$ of carbo-hydrates, 1 of salt, total, $22\frac{3}{4}$ ozs. (Moleschott). This is equivalent to a little over 40 ozs. of moist solid food. If we add 40 to 60 ozs. of water, we have a complete diet.

Estimation of Diet.—Reckoning 300 grains of nitrogen, and 4,800 of carbon, as the amount required, it is found that this is yielded by a combination of $\frac{3}{4}$ lb. meat and 2 lbs. of bread, that is 44 ozs. of solid food. If one subsisted on beef alone, $2\frac{2}{3}$ lbs. would be required to furnish enough carbon, and there would be a considerable surplus of nitrogen. Similarly, if one lived on bread alone, to get 300 grs. nitrogen, $3\frac{1}{3}$ lbs. of bread would be required, and this would supply a large excess of carbon.

Again, if one lived on eggs alone, which, averaging $1\frac{3}{4}$ ozs. in weight, yield 2 per cent. nitrogen, or nearly 18 grains, in order to obtain 300 grains nitrogen, 17 eggs would have to be eaten.

It is evident from the above instances that the most economical diet is that which contains both nitrogenous and carbonaceous substances, and that no one article of diet furnishes these in a suitable ratio. By combining bread with meat, one obtains the highest amount of nutritious matter with the least amount of waste matter. Similarly, a combination of butter-milk with potatoes, or of broad-beans and bacon, to take common examples from the diet of farm-labourers, furnishes a useful and economical meal.

If one has a table such as the following from Parkes, showing the number of grains of carbon and nitrogen in an ounce of various foods, it is easy to calculate the amount of such food necessary, and so to combine them as to have no waste of either nitrogenous or carbonaceous material.

NOTE.—Further particulars on the subject of this chapter, with examples of problems worked out, will be found at page 412.

Table showing the number of Grains of Water, Nitrogen, Carbon, and Salts in one ounce (=437½ grains) of Various Substances.

	WATER.	NITROGEN.	CARBON.	SALTS.
Uncooked beef	328	10·35	64·	7
Uncooked fat beef ...	275·6	9·6	98·3	16
Cooked beef	236	19	117·7	13
Salt beef	215	20·4	69·7	92·3
Salt pork	192	18·	85·	99·7
Fat pork	170	6·8	192·	10·1
Dried bacon	65·6	6·1	273·8	12·7
White fish	341	11·5	52·4	4·4
Poultry	324	14·5	62·	5·2
Bread	175	5·5	119	5·6
Wheat flour	65·6	7·6	169	7·4
Biscuit	35	22·7	183	7·4
Rice	43·7	3·5	176	2·2
Oatmeal	65·6	8·7	172	13
Maize	59	7	176	6
Peas	65·6	15	161	10
Potatoes	324	1	49	4·4
Carrots	398	·4	18	3·
Butter	26	·2	315	11·8
Egg	321	9·3	71·5	4·4
Cheese	161	23	162	23·6
Milk	380	2·75	30·8	2·6
Cream	289	1·9	93·5	7·9
Skimmed milk	385	2·8	25·	3·5
Sugar	13	——	187·	·2

CHAPTER VI.

THE PREPARATION AND PRESERVATION OF FOOD.

Objects of Cooking.—Methods of Cooking: Roasting, Boiling, etc.—Cooking of Mixed Dishes.—Cooking of Vegetables.—Bread.—Potatoes.—Kitchen Utensils.—Cooking Ranges.—The Preservation of Food.

Objects of Cooking.—Food is required to restore the waste elements of the tissues, and to supply oxidisable material, by

means of which the heat and other forces of the system are maintained.

The food may be taken in its crude and unprepared condition, as directly derived from the animal or vegetable world, or after it has undergone a preparatory process of cooking. Man is the only animal who cooks his food, and has been distinguished from the lower orders of creation by the title of the "cooking animal." Many foods, in the uncooked condition, are almost entirely incapable of digestion by him—such as the proteid and farinaceous materials contained in the seeds of cereal and leguminous plants, and in the tubers, roots, and succulent stems of various vegetables. But cooking, as a preparatory help to the digestion of food, is not equally required by all foods. Thus, fruit is commonly taken uncooked, and does not undergo any important alteration on cooking. Salads are taken uncooked, but not for their nutritive properties so much as for a relish to other foods, and for their quasi-medicinal properties. Milk, again, may be taken cooked or uncooked. The oyster is the only animal which is eaten habitually, and by preference, in the uncooked condition; and it is interesting to find that there is a physiological reason for this universal custom. The large fawn-coloured liver, which constitutes the delicacy of the oyster, is little else than glycogen, associated with its appropriate ferment diastase (W. Roberts), so that the oyster is almost self-digestive. When cooked, the ferment is destroyed, and digestion of the oyster becomes much more difficult.

Cooking is intended—1. *To make the food softer*, and in part to mechanically disintegrate it, thus rendering it more easily masticated and digested. In fact, cooking, in the best sense, is an artificial help to digestion; and digestion may well be said to commence in the kitchen.

2. *To produce certain chemical changes.* Thus, starch is partially converted into dextrine; gelatin is formed from the connective tissue of tendons, etc.

3. *To destroy any noxious parasites* present in the food, or to

obviate any ill effects from *putrefactive changes.* Diseased meat probably only produces bad effects when imperfectly cooked.

4. *To make the food more pleasant* to the eye and agreeable to the palate. The improved savour in cooked meat, for instance, has a very appetising effect, and consequently makes digestion much easier.

The Cooking of Flesh.—1. **Roasting** is, perhaps, the most perfect way of cooking meat. It exalts its flavour more than any other method. In roasting, place the meat at first sufficiently near a brisk fire, so that the albumin on its surface may be readily coagulated, and the juices retained in the interior of the joint. After about fifteen minutes, the joint ought to be removed somewhat further from the fire, and allowed to cook slowly. Frequent basting is desirable to obtain a good result. Brown meats, such as beef, mutton, and goose, require a quarter of an hour per pound weight; veal and pork require about ten minutes additional, to ensure the absence of redness. White-fleshed birds require a somewhat shorter time. The time required in roasting will be a little more if the joint is large, or the fire not very clear. To ascertain if the meat is done, press the fleshy part with the finger; if it remains depressed, it is done; if not done, it retains its elasticity. At the first incision, gravy should flow out, of a reddish colour.

The changes undergone during roasting are, that the connective tissue uniting the muscular fibres is converted by the gradual heat into gelatin, which is soluble and easily digested; the muscular fibres, consequently, become more separable, and the myosin of which they consist is rendered more digestible. The fat is partly melted out of its fat cells, and partly combines with the alkali from the blood-serum. Empyreumatic oils, developed by charring of the surface of the joint, are carried off when it is roasted in front of the fire; and so, to a large extent, is acrolein. Acrolein (C_3H_4O) is always produced by the destructive distillation of neutral fats containing glycerine, and is the cause of the intolerably

pungent odour accompanying the process. Osmazome, a peculiar extractive matter, on which the flavour and odour of meat depend, is developed better by roasting than by any other method of cooking.

It is useful to remember, in buying beef or mutton, that 20 per cent. must be allowed for bone and 20 to 30 per cent. for the loss during cooking. Thus, a joint of sirloin of beef, weighing 12 lbs., lost in roasting 44 ozs., of which 27 ozs. were water and 17 ozs. fat or dripping. With boiling, if well done, there is not so much loss.

2. **Baking** of meat in a closed oven does not produce so good a result as roasting in front of an open fire. The oven ought always to be very hot before the meat is put in, in order to rapidly coagulate its surface. Baked meat commonly has an unpleasant flavour, owing to its saturation with empyreumatic oils, which escape in open roasting. The unpleasant flavour may be prevented by covering the meat with a layer of some non-conducting material, as a pie-dish or a crust, no empyreuma being then formed. Baked white of egg, as in the common dish of fried ham and eggs, is one of the most indigestible forms of albumin obtainable.

3. **Boiling** of meat requires the same time as roasting. If the flavour and juices are to be retained, the joint ought first to be plunged into soft boiling water, and then, after three minutes, allowed to stand aside to simmer in water at 180° Fahr. The preliminary boiling forms a coating of coagulated albumin over the joint. Where there is no thermometer to guide the cooking—after the preliminary boiling for three to five minutes, add three pints of cold water to each gallon of boiling water, and retain at the same temperature for the rest of the process, *i.e.*, at about 170° Fahr.

The use of soft water for cooking purposes is always advisable; otherwise a longer period must be allowed. A preliminary boiling for a few minutes renders water much softer, and the addition of a little carbonate of soda has a like effect.

When meat is inserted in water at a temperature below its

boiling point, the juices are gradually extracted, while the meat is left a mass of hard strings, in many cases equally wasted whether eaten or not. A nourishing soup is produced, but the meat is almost valueless. In order that soups and broths may be nutritious, the less heat is employed in their preparation the better. If a soup is strained to make it clear, much of the most valuable part is removed.

4. **Stewing** is a process intermediate between boiling and baking. It possesses the great advantage over dry baking that no empyreumatic gases are produced, and there is no charring. The temperature of the stew-pan ought never to be above 185° Fahr.; at this heat the roughest and coarsest kinds of meat are made tender. The only objection to stewing is that the meat becomes saturated with fat and gravy, and is too rich for weak stomachs. It is advisable to stew lean meats only.

Hashing is a process of stewing applied to meat which has been previously cooked. The consequence of this double cooking is, that the meat becomes tough and leathery. A modified hash, in which the meat is simply well warmed throughout, is very preferable. Tinned meats (American mutton, beef, etc.), are not uncommonly hashed. This is a bad plan; the meat has already been over-cooked during the process of tinning. It ought to be eaten cold with its own jelly and a salad, or simply warmed through.

5. **Frying**, unless carefully done, renders meat difficult of digestion, each fibre becoming coated with fat, and empyreumatic and other rancid acids being freely produced. The art is to "fry lightly," that is, to burn quickly and evenly, so that no charring is produced. Two methods of frying are described. In the first, the substance to be fried, as an omelette or sole, is placed with a little fat or oil in a frying-pan. In the second, the substance to be fried is immersed in fat; for this purpose a frying kettle is required. The fat in all cases must be heated before the meat is inserted, in order that the juices of the latter may become encased in its

interior. By means of fats or oils a much greater heat can be applied to meat, than by water; as the former do not boil below 500 – 600° Fahr. The higher the temperature of the fat, the less digestible the fried substance becomes.

6. **Broiling and grilling** are really processes of roasting applied to small portions of meat. In the latter process, it is important that the gridiron should be hot before putting anything on it. An external coagulation of albumin is produced, as in good roasting and boiling.

We may mention here the results of Dr. Beaumont's experiments on Alexis St. Martin, as to the time required in digesting an egg prepared in different ways. He found that an egg whipped and diluted with water required $1\frac{1}{2}$ hours; fresh, raw, and undiluted, 2 hours; fresh, roasted, $2\frac{1}{4}$ hours; soft boiled or poached, 3 hours; hard boiled, $3\frac{1}{2}$ hours; fried, $3\frac{1}{2}$ hours. As eggs consist largely of albumin, they may be taken as fairly typical of all nitrogenous foods.

The Cooking of Mixed Dishes.—It will only be possible to give a few instances of common errors in preparing compound dishes, though the subject is by no means unimportant. An egg, for example, may be a light and easily-digested food, or almost as hard and impervious to the digestive juices as leather. In a custard or just coagulated in a poached egg, it is the former; baked half an hour in a pudding, it is the latter, and is useless as regards nutritive properties, besides being likely to produce indigestion. Spices, if mixed with a dish before it is boiled, lose nearly all their flavouring power, while they remain irritating. They ought to be added near the end of the cooking process. A soup containing vegetables, as well as meat juices, should be prepared in two parts. The vegetables require prolonged boiling; gravy is spoilt by this.

Similarly, the jam in a tartlet, if inserted before baking, loses its proper fruity flavour; and oysters baked in a beef-steak pie are indigestible, and almost useless.

The Cooking of Vegetable Foods.—**Bread is either vesiculated or unvesiculated**; the latter being what is called unleavened bread. Vesiculation of bread has usually been produced by *fermentation* of some of the sugar of the flour. The starch first becomes dextrose, and then the growth of the yeast plant in the dough splits this up into alcohol and carbonic acid gas. The carbonic acid percolates the substance of the dough, rendering it porous. When it has "risen" sufficiently, the dough is placed in the oven. The heat of the latter kills the yeast plant, thus preventing any further fermentation, but at the same time expands the carbonic acid gas in the bread, rendering it still more porous.

It is objected to this plan of making bread, that some of the sugar is wasted in producing carbonic acid. To remedy this, *another plan* is sometimes adopted, as first proposed by *Dr. Dauglish.* In it the dough is charged with carbonic acid dissolved in water under considerable pressure. The gas escapes in the substance of the dough, and on baking expands as in the ordinary method of making bread. Bread made in this manner, is called "aerated bread."

A modification of this plan is commonly employed on the continent, in which a mixture of hydrochloric acid and carbonate of soda is used, thus generating carbonic acid in the dough, and forming common salt. The hydrochloric acid employed should be perfectly pure and free from arsenic.

Ten pounds of flour ought to make thirteen to fourteen of bread. The use of stale bread is much more economical than of newly-made bread; besides this, it is more digestible. Newly-made bread is more palatable than stale, but is more cohesive, and does not crumble into separate particles like stale bread. The consequence is, that it is less digestible, being less easily penetrated by the saliva and other digestive juices. The effect of *toasting* is to render bread more friable, and consequently more digestible. It ought, however, to be thin and eaten soon after it is made; when thick and kept too long, it becomes tough and leathery.

Pure white bread is usually considered to be less nutritious than that made from seconds flour or from whole meal. According to Wagner's recent researches, however, the nitrogenous matter contained in the bran is mainly alkaloidal and not albuminoid, and hence useless as a food. It would seem, therefore, that the idea of the nutritive quality of the bran, founded on its high per-centage of nitrogen, is erroneous.

Pastry is less easily digested than ordinary bread. The lard or dripping added render it more flaky and less easily pulverised; and, in addition, the fat coats over the starch cells; and thus the action of the digestive juices on the pastry is impeded. Puddings made with suet are considered to be more digestible than those made with dripping or lard.

Potatoes, when boiled, ought to be inserted in boiling water. If put into cold water, and then the temperature gradually raised, much of the starch is changed into a gelatinous condition, and may mix with the water. When starch cells—whether in potato, bread, or any other food—are heated to the boiling point of water, they burst and liberate the starch granules in their interior, thus rendering them capable of being acted on by saliva. This is the chief object of cooking starchy foods. When starchy foods are boiled with water a further change occurs, the starch granules being converted into gelatinous starch. In this condition the starch is still more digestible. By baking or frying potatoes, dextrine ($=C_6H_{10}O_5$) may be produced, which must not be confounded with dextrose (*i.e.*, glucose $= C_6H_{12}O_6$).

Potatoes ought be steamed rather than boiled, on account of the possible loss of some starch in the latter process. Potatoes are more digestible when mashed; when underdone, they are very objectionable.

Peas and **Beans** ought to be boiled slowly and for a long time; otherwise they are very indigestible. If old, they ought to be soaked in cold water for twenty-four hours, then crushed, and stewed. Hard water must be avoided in the cooking of peas and

beans as well as of other vegetables, as the lime-salts form insoluble compounds with legumin.

Green vegetables require thorough and prolonged cooking. This deprives them of much air, and renders their tissues softer and more easily attacked in digestion. The members of the cabbage tribe and carrots can hardly be boiled too long. Soft water ought always to be used; this is one reason why steaming is preferable. Before boiling, all vegetables should be well washed in cold water. A little vinegar will remove any insects present.

COOKING APPARATUS.—The apparatus required in cooking may be divided into kitchen utensils and cooking ranges. It will only be necessary to mention the most important of them.

Among kitchen utensils the **frying-pan** holds an important though much abused position. It is essential that it should be kept thoroughly clean, and that any given dish should not taste of its predecessor. Fat used for frying fish should not be used for any other purpose, unless the fish has been most carefully surrounded by bread crumbs.

The **gridiron,** if carefully employed, is a valuable means of cooking chops or steaks, etc. The bars of the gridiron should be kept perfectly clean; they should be heated before the meat is put on them; the meat should be turned by means of proper tongs, and never pierced by a fork; and the fire should be bright and clear.

The **saucepan** is useful for various purposes, such as boiling and stewing, and is an essential item in kitchen utensils.

A **digester,** of which Papin's digester is perhaps the most perfect form, is a strongly closed vessel in which substances may be boiled under pressure, the steam not being allowed to escape. By this means a much higher temperature can be applied, and all the gelatin extracted from bones, etc.

The **spit** is used for roasting large joints, and it has the great advantage over the oven, that empyreumatic oils are dispersed, and that the process of cooking is under the cook's eye, who can baste at frequent intervals.

The **Dutch oven** is of great use for broiling small pieces of meat, and it combines the advantages of roasting and baking.

The chief forms of cooking ranges are the open range, the closed range or kitchener, the gas stove, and the charcoal stove.

An open fire range ensures good ventilation, and is consequently healthier than any form of closed range. On the other hand, it consumes an inordinately large amount of fuel; it is liable to produce smoke and dust, and only a very limited number of dishes can be cooked at the same time. It has been estimated that with an ordinary open fire-place, seven-eighths of the heat produced ascends the chimney and is entirely lost. More modern arrangements have diminished this loss, but it is still very great.

The best argument in favour of an open range is, that it allows the roasting of meat in front of the fire, a method of cooking which is unequalled by any other.

Kitcheners are, if properly attended to, economical of fuel; but if the cook is ignorant or careless, may burn more than an open range. They are advantageous, in that there is no danger of the downfall of soot during cooking, and that several different things can be cooked at the same time. The chief objections to them are, that they make the air of the kitchen hot and dry; that if there is any boiling over, commonly there is not sufficient ventilation to carry off the smell; that they require more care in management than an open range; and that in using them one cannot constantly baste a joint, as in roasting it before an open fire.

Gas stoves are very cleanly, and always ready for use. The consequences of tardy attention to fuel are not felt with them; and the amount of heat can be exactly and immediately regulated. When a constant fire is required, gas stoves are more expensive than other forms; and meat baked in gas stoves is said occasionally to have an unpleasant flavour. Much will depend on the ventilation of the stove (as also in the other forms).

Charcoal stoves are extensively used on the continent, and produce great heat without any flame. The fumes from burning

charcoal (largely composed of carbonic oxide) are extremely dangerous, unless there is free ventilation, and a proper flue.

The economy and utility of the different ranges vary greatly with the management. A good cook may produce good results from any of them. Probably the most useful form is a combination of an open range and kitchener.

THE PRESERVATION OF FOOD.—All kinds of food tend rapidly to decompose and putrefy. Putrefaction only occurs when a warm and moist substance is exposed to the air. The problem of preserving any food, therefore, may be solved (1) by keeping it at a very low temperature, (2) by desiccating it, or (3) by boiling it in some liquid, so as to drive out all air, and then fastening it in an air-tight case.

Milk is commonly preserved as condensed milk, and in this condition is very valuable. A pure condensed milk is now supplied, prepared without the addition of sugar or any antiseptic, but boiled so as to deprive it of any disease germs. Milk may also be desiccated; in this condition it is difficult of digestion.

In addition to the household methods of preserving fruits, large quantities of fruits—both moist and dry—are now imported, protected by syrup or sugar, in sealed canisters; and they retain the original flavour almost unchanged.

The preservation of meat is effected by—

1. **Drying.**—This must be done rapidly. It is a process which is best applicable to fish, but has been applied also to beef. Dried Hamburg beef is used for making sausages, and is very nourishing. Pemmican, largely used by Arctic voyagers, consists of a mixture of meat and fat, dried and powdered along with some spices; it is generally eaten with some kind of meal.

2. **Cold.**—A sufficiently low temperature to destroy putrefactive germs, is now used as a means of bringing fresh meat from the United States weekly, and less frequently from Australia and New Zealand. A considerable amount of such meat is sold in the market as English meat.

3. **Salting** may be done with brine or saltpetre (nitrate of potassium); the latter does not decolourize the meat like the former. According to one plan (Morgan's), the brine is injected through the capillaries from the aorta directly after killing the animal. The objections to salted meats are that half the nutritive material, in the form of albumin and salts, is removed, while the remaining meat is harder and more difficult of digestion; also that the flavour of the meat is altered, and the excessive amount of foreign salts is injurious.

4. **Immersion in antiseptic liquids** or gases, as sulphite of soda, is objectionable, on account of the addition of extraneous, and not altogether innocuous, salts. Boro-glyceride, a compound of boracic acid and glycerine, is tasteless and non-poisonous, and is valuable in preserving meat from tainting during a hot season.

5. **Coating with fat or gelatine** has only succeeded in conjunction with the exclusion of air. This process is especially applicable to fishes, as tinned sardines. In a modified form, it is useful in coating potted meats, etc.

6. **Pressure**, by means of which the juices are extracted, is useful in preserving meat; but the resulting substance must be regarded as meat *minus* some of its most important constituents.

7. **Heating and Air-tight Cases.**—This plan has been found very useful, and is commonly adopted; tinned meats prepared according to this method being imported in large quantities. They are cheap, and might be adopted with great advantage to a much larger extent by the poorer classes. In the process of preparation, the cases are packed with meat and filled up with gravy, and then closed with a cover which is hermetically sealed, except at one point. The case is then heated to 250° Fahr., in order to drive out all air, and destroy any putrefactive germs present. The open point is sealed while the gravy is still boiling, thus making the case completely air-tight. Albumin is coagulated at about 170° Fahr.; the higher temperature, which it is found necessary to employ, overcooks the meat and renders it rather less digestible.

CHAPTER VII.

CONDIMENTS AND BEVERAGES.

Use of Condiments.—Condiments Proper.—Spices.—Flavouring Agents.—Acids.—Aërated Waters.—Mineral Waters.—Tea: Constituents, Mode of Preparation, and Effects.—Coffee: Constituents, Mode of Preparation, and Effects.—Cocoa: its Varieties and Preparation.—Minor Stimulants.

Condiments, etc.—The name condiment is used in various senses by different writers. In its strictest sense it is a substance containing a volatile oil or ether, which may be taken with salt, and the object of which is to excite the senses of taste and smell, and consequently produce an appetising effect. This definition excludes *spices*, substances allied to condiments, but usually taken with sugar, as cinnamon, ginger, etc.; also *flavouring agents*, such as vanilla; and *acids*, such as vinegar and lemon-juice. If we use it in its widest sense, to include these various groups of substances, we find that all condiments are taken with the object of improving the taste or flavour of food, or of assisting its digestion; but that they are not foods in the sense of supplying any elements towards building up the body or maintaining its heat. The only partial exception is lemon-juice, the salts of which have a quasi-medicinal use, in addition to their utility in exciting the nerves of taste.

Taste is usually a compound sensation, the organs of which are the nerves of taste (in the tongue) and smell (in the nose). True taste is confined to the appreciation of sensations of bitter and sweet; but the flavour of meats is nearly entirely appreciated by the sense of smell. This is shown by the fact that meats appear tasteless and insipid, during "a cold in the head." In the appreciation of acid, astringent, and fiery substances, the sense of touch is also employed. The excitement of these different nerves results in

a stimulus which is carried up to the central nervous system, and causes, by reflex action, an increased flow of the digestive juices. Hot substances, like cayenne and ginger, also cause an increased flow of gastric juice, by directly congesting the mucous membrane. This action is not so desirable as that through the influence of the nervous system. All natural foods are sapid and possessed of flavour, and thus stimulate the nervous system; but any local irritating effect ought to be avoided.

1. **Condiments** proper comprise chiefly mustard, pepper, cayenne, garlic, onion, capers, mint, sage, morels, mushrooms, truffles. The last three on the list are also foods, but are more commonly used as condiments.

All these act as stimulants to the digestive organs, and in small quantities aid digestion. The active principle of mustard and horse-radish is sulphocyanide of allyl. Horse-radish is not so wholesome as mustard, the scraped root being apt to adhere to the stomach like the skins of grapes, and produce indigestion. Pepper contains an acrid resin, a volatile oil, and an alkaloidal substance, called piperine. Cayenne contains an analogous substance, called capsicin. Cayenne, unless in extreme moderation, is harmful, as its small particles adhere to the mucous membrane of the stomach, and may set up considerable irritation.

2. **Spices** are those condiments which contain an aromatic oil, and which harmonize with sugar. They are, as a rule, less irritating to the stomach than those of the pepper group. Cinnamon, cloves, camphor, ginger, and curry powder are the chief of these. Curry powder really belongs to both the first and second divisions. It is much more commonly used in hot climates than in this country. When genuine, it is said to contain turmeric, cardamoms, ginger, allspice, cloves, black pepper, coriander, cayenne, and a few other substances.

3. **Flavouring agents**, such as vanilla, lemon peel, fruit essences, and oil of bitter almonds, are used to give a pleasant flavour to various dishes. The oil of bitter almonds is dangerous, owing to

the uncertain, but often large, amount of prussic acid contained in it. Its place is being largely taken by nitro-benzol, which is rather less poisonous.

4. **Acidulous** substances are taken chiefly because of their sharp and agreeable taste. Vinegar is the chief acid employed. In small quantities it does not stop digestion, but, by exciting the nerves of taste, may be of actual service. With salads it is invaluable; also for use with shell-fish and for pickling fish, etc., in warm weather. In large quantities it diminishes the power to assimilate food, and for this reason has been proposed as a remedy for obesity. In order to remedy the latter, however, it must be taken in injurious quantities. Citric acid and lemon-juice are useful for their refreshing properties, and the latter also because of its alkaline salts.

Oils, such as salad oil, have been sometimes classed under condiments, but as they have great nutritive properties, this is hardly accurate. For the same reason, **salt** is not classed under this head.

Beverages.—Water is the universal beverage, and for healthy persons is preferable to any other. All other beverages necessarily contain it as their basis.

It will be convenient to consider first aërated and other natural waters; then tea, coffee, and cocoa; and finally, alcohol.

1. **Aërated Waters,** of which soda water may be taken as the type, contain carbonic acid in solution, which gives to them their characteristic sharp taste and sparkling character.

So-called **Soda Water** is prepared on a large scale as follows:—Carbonic acid is obtained by the action of diluted sulphuric acid on chalk, sulphate of calcium being left behind. The carbonic acid is forced into water, which dissolves about five times its volume of the gas. This preparation is simply a solution of carbonic acid in water under pressure; the true soda water, however, consists of a solution of thirty grains of bicarbonate of soda in a pint of water, saturated with carbonic acid at a pressure of seven atmospheres.

Soda water acts as a sedative to the mucous membrane of the

stomach, and is therefore useful for vomiting. Mixed with milk it renders the latter much more digestible for two reasons :—1st—It neutralises any acids present, which have been produced by partial fermentation and souring of the milk. One of the chief reasons why cow's milk is apt to disagree with babies is, that it tends to become acid, while human milk is alkaline. 2nd—The dilution of the milk renders what clot is formed much less dense and heavy.

Potass Water is prepared by passing carbonic acid gas under a pressure of seven atmospheres into a solution of thirty grains of bicarbonate of potass in a pint of water. It is antacid in its action, and is very useful in certain gouty conditions. The carbonic acid it contains, as in the case of soda water, has a sedative influence on the stomach.

By means of an apparatus called a seltzogene or **gazogene**, simple carbonic acid water can be prepared at home. A solution of tartaric acid acts on bicarbonate of soda, and the carbonic acid obtained is dissolved under pressure in water. It is very useful as an addition to milk ; and with various fruit syrups and water forms a most agreeable beverage.

In addition to the above, there are many other aërated waters, which are used partly as beverages and partly for their medicinal properties. Of these, perhaps seltzer and apollinaris waters are the most popular.

The accompanying tables give the composition of these two favourite waters :—

Analysis of Seltzer (Bergmann).—Sp. gr. 1·0027.

Each Wine-Pint contains—	
Carbonic Acid	17 cub. inch
Carbonate of Soda	4 grs.
Carbonate of Magnesia	5 ,,
Carbonate of Lime	3 ,,
Chloride of Sodium	17 ,,
	29 ,,

Analysis of Apollinaris Water made by Professors G. Bischof and Mohr, and Drs. C. Bischof and Kyll.

FIXED CONSTITUENTS OF 10,000 PARTS.		
	OLD ANALYSIS.	MEAN OF EIGHT ANALYSES MADE DURING THE YEAR 1877.
Carbonate of Soda	12·57	9·555.5
Chloride of Sodium	4·66	3·764.5
Sulphate of Soda	3·00	2·124.25
Phosphate of Soda...	Traces	—
Salts of Potash	Traces	—
Carbonate of Magnesia	4·42	3·775
Carbonate of Lime...	0·59	2·608
Oxide of Iron, with Alumina ...	0·20	0·068.5
Silicic Acid	0·08	0·137
	25·52	22·032.75

VOLATILE CONSTITUENTS.	
Free and semi-combined Carbonic Acid	27·76
Combined Carbonic Acid	8·07
	35·83

Lemonade is commonly a very dilute solution of sulphuric acid, flavoured with oil of lemons, and impregnated with carbonic acid. It occasionally contains an injurious amount of lead, especially when kept in syphon bottles. Home-made lemonade, obtained by squeezing the juice of a lemon into water, sweetening to taste, and then, if desired, impregnating with carbonic acid from a gazogene, is much more wholesome.

In addition to aërated waters, there are other mineral waters, employed chiefly for their medicinal properties. These are chalybeate, saline, or sulphuretted.

Chalybeate Waters owe their value to the iron they contain.

This may exist as carbonate of iron, held in solution by excess of carbonic acid, as in Tunbridge Wells and Harrogate waters; or as sulphate, as in the waters of Sand Rock (Isle of Wight), Brighton, etc.

Saline Waters contain various salts, and may be sub-divided according to the nature of these. Some contain sulphates of magnesia and soda, as those of Seidlitz, Carlsbad, Püllna, and Friedrichshall. Some contain chiefly carbonate and sulphate of lime, as those of Buxton and Bath. Some contain chiefly chlorides, as those of Baden-Baden and Kreuznach; while others contain a large amount of alkaline carbonates, as those of Vichy and Ems.

The following table, from Sir H. Thompson's work, gives a comparative synopsis of the chief saline contents per pint in some important mineral waters, omitting common salt and other less active agents, which are also present:—

	SULPHATE OF SODA	SULPHATE OF MAGNESIA	CARBONATE OF SODA	OTHER INGREDIENTS
Saline:—				
Püllna	154 grs.	116 grs.	—	—
Hunyadi Janos ...	150 ,,	148 ,,	—	—
Friedrichshall... ...	58 ,,	49 ,,	—	Little Iron.
Marienbad (Kreuz)	48 ,,	—	9 grs.	Little Iron.
Carlsbad (Sprüdel)	25 ,,	—	13 ,,	Little Iron.
Franzenbad	30 ,,	—	6 ,,	Little Iron.
Alkaline:—				
Vichy (Celestins) about	3 ,,	—	47 ,,	Little Iron.
Vals (Magdeleine) about	—	—	65 ,,	Little Iron.

The following table gives a more detailed analysis, by Schwartz, of the constituents of a pound (7,680 grains) of some of the chief German mineral waters :—

CHEMICAL INGREDIENTS	Hunyadi	Fried-richshall	Kis-singen	Seid-schütz	Püllna	Seidlitz
	Vienna Grains					
Sulphate of Magnesia ...	137·98	39·55	39·50	84·16	93·08	104·00
Sulphate of Soda	128·97	46·51	46·59	46·80	123·80	—
Sulphate of Potash ...	1·67	1·52	—	4·09	4·80	—
Chloride of Sodium ...	11·54	61·10	61·10	—	—	—
Carbonate of Soda ...	13·20	—	—	—	—	—
Carbonate of Lime ...	6·04	0·11	—	—	0·77	8·00
Oxide of Iron and Argillaceous Earth ...	0·08	latent	—	1·19	—	—
Silicic Acid	0·09	„	—	0·03	0·17	—
Carbonate of Magnesia	—	3·99	—	4·98	6·40	3·00
Sulphate of Lime	—	10·34	—	10·07	2·60	8·00
Chloride of Magnesium	—	30·25	30·20	2·16	19·66	3·00
Nitrate of Magnesia ...	—	—	—	25·17	—	—
Bromate of Magnesia ...	—	0·87	latent	—	—	—
Chloride of Lithium ...	—	—	0·09	—	—	—
	299·57	194·24	177·48	178·65	251·28	126·00
Carbonic Acid, free and half combined	8·02	5·32	5·09	latent	latent	—

Sulphuretted Waters contain sulphuretted hydrogen in solution, and commonly an alkaline sulphide. They are readily recognised by their odour. Harrogate and Aix-la-Chapelle waters are instances of this kind of mineral water. They are useful chiefly as stimulants to the skin and in rheumatism.

Tea.—Tea is the leaf of an evergreen shrub which is cultivated in China, and to a less extent in Japan, British India, Ceylon, Java, and other countries. In 1871, the consumption of tea in the United Kingdom was 3 lbs. 15 oz. for each individual.

The finest tea consists of the first young leaf-buds. The chief

gathering of leaves takes place later in the year; and a third gathering, when the plant is somewhat exhausted, supplies an inferior quality. The flavour of tea depends largely on the nature of the soil and situation, on the time of year when the leaves are gathered, and on the mode of preparation. A genuine Congou tea may be obtained for two shillings a pound or less, while two guineas per pound may be given for the Russian caravan tea; the difference in price being to some extent justified by the difference in flavour. The amount of theine in both is the same, viz., about three per cent. Where expense is no consideration, ordinary Congou may be mixed with some of the choicer varieties of tea, such as Souchong, Kaisow, or Orange-flavoured Pekoe.

There are four leading constituents in all the varieties of tea, viz.: (1) volatile oil, (2) theine, (3) gluten, (4) tannin.

(1) The **Volatile Oil** gives the aroma and flavour to each particular tea. It is this which causes the headache, trembling, wakefulness, and restlessness, occasionally produced by tea. These effects generally follow the use of green tea and fresh new tea, which contain a larger amount of volatile oil than ordinary black tea. Green tea is prepared from the young leaves, and is dried more rapidly than black tea, which may explain the larger amount of volatile oil contained in it.

(2) **Theine** is an alkaloidal crystalline principle, rich in nitrogen. Its composition is represented by the formula $C_8H_{10}N_4O_2$, H_2O, and it is identical with the caffein of coffee. It is allied to quinine in composition, and in large doses would be poisonous. The theine in tea may amount to three or four per cent.; in coffee it is less than one per cent. (0·8). There is no difference in the amount of theine in black and green tea.

Theine is the most important constituent of tea and coffee. It will be convenient here to consider its effects on the system. Moderate doses increase the strength and rapidity of the heart's action; the activity of the brain is usually increased at the same time. The excretion of solids by the kidneys is increased, so that

tea forms a useful diuretic in some forms of dropsy. The effect on the tissue-changes of the body is somewhat doubtful. It is generally stated to arrest or diminish the waste, or rather the oxidation, constantly going on in the system, and so diminish the amount of food required to repair this waste. This is, however, very doubtful; we cannot conceive the likelihood of the development of force without a corresponding expenditure of material, and that is what would be the case if theine increased the activity of various organs while retarding their waste. The experiments of Conty and Guimarès on the action of coffee, confirm this view. They find that this (and tea has the same essential constituent) is not a preventer of tissue waste; but that the nutrition is improved by it, because, when not taken in excess, it increases the appetite and the assimilation of nitrogenous food.

(3) **Gluten** is contained in tea leaves, and gives them a positive nutritive value; very little of it is, however, obtained when an infusion of tea is made. The addition of soda to the water extracts more of it; and the Japanese grind the leaf to powder, and, after making an infusion with boiling water, drink powder and all.

(4) **Tannin** exists in tea to the amount of 15 to 20 per cent. It is a powerful astringent, and possesses a bitter styptic taste, and a constipating effect on the bowels. The amount of tannin is greater in Indian than in China tea. It is increased by long "brewing," but even in tea infused for a short time, there is a considerable amount, as tannin is very soluble in hot water.

The Mode of Preparation of Tea is of great importance. According to the plan pursued, tea may form a pleasant, refreshing, and stimulating beverage, or a liquid capable of exciting severe indigestion. The Chinese put the tea leaves in a cup, and having poured hot water on it, drink the resulting infusion after a very short time, without mixing any other material with it. The Russians drink it with a squeeze of lemon, and with or without sugar. We add cream or milk and generally sugar, and so render it more nutritious, though the delicate flavour is somewhat veiled. There can be no doubt that the Chinese plan of infusion for a

short time is the best, as it ensures the extraction of the aromatic and stimulant principles of the tea without the tannin.

In making tea it is important to use a tea-pot which is quite dry, in order to avoid mustiness; to pour a small quantity of boiling water into the tea-pot and then out again, so that the infusion may be made at the temperature of boiling water; to use moderately soft and boiling water, pouring it on the tea-leaves; and not to infuse longer than five minutes, keeping the tea-pot under a "cosy" during this process. For persons of weak digestion, the best kind of tea is that obtained by pouring boiling water on the leaves, and then immediately pouring the resulting infusion into another vessel. In all cases where tea has to be kept a considerable time, it should be poured into a second tea-pot, the leaves being left behind.

Indigestion is not an uncommon consequence of tea-drinking. It is not always due to the same cause. In some cases it is due to the liquid being drunk too hot; in others, to the tea itself (aromatic and alkaloidal parts); and in others, to the tannin; while in some cases it is certainly due to the mode of drinking the tea.

The most injurous material in tea is probably tannin; and it has been already stated that the amount of this is greatly increased by long infusion. Tannin retards digestion, and produces constipation. Badly-made tea ought, therefore, never to be taken with a substantial meal. The tannin coagulates albumen, and prevents its solution by the digestive juices. For this reason "high teas" and "tea-dinners" are objectionable.

The practice of drinking tea in small sips, with bread and butter, etc., is a prolific source of indigestion. The bread ought to be moistened by the saliva, and thus its digestion helped; but when the tea infusion usurps the place of the saliva, the stimulus to the nerves governing the secretion of saliva is gone, and the secretion becomes deficient. Tea ought only to be drunk at the end of a meal, and, in fact, it would be much better if "tea" were not made so complete a meal, as it commonly is at the present time

among the middle and lower classes. The practice of drinking tea with every meal is inexcusable.

For quenching thirst during active exercise, and rendering possible prolonged exertions, tea is unsurpassed. On the continent, and wherever the drinking-water is unreliable, weak tea or some other beverage ought to be substituted. The mineral waters, such as Apollinaris and Seltzer, come in useful here, and are much safer than the water which is commonly offered to travellers.

Coffee.—Coffee is the seed of the berry of the *Coffea Arabica*, belonging to the same class of plants as yields the Peruvian bark. Each berry contains two seeds, or beans as they are sometimes incorrectly called. The coffee is prepared by roasting the seeds until they assume a reddish-brown colour, in which process they lose 15 per cent. in weight and gain 30 per cent. in bulk. During the process of roasting, a volatile oil, having a powerful aromatic smell, is developed. This is not produced in such large quantities from fresh seeds; the best time for roasting varying, however, for different varieties of coffee. Thus the small Mocha seeds will yield a full-flavoured coffee within a year of their being collected; the larger American coffee, if roasted within a year, develops but a poor aroma, but if kept for seven or eight years becomes quite as aromatic as the Mocha. A mixture of one part of Java and two parts of Mocha coffee seems to yield a more aromatic beverage than either of the two alone (Brunton).

The amount of **Volatile Oil** in coffee is much less than in tea. As it is elicited during the process of roasting, it is essential that this should be done with great nicety and care. It is performed in an iron cylinder made to revolve over a fire. After the roasting, the sooner the seeds are ground the better the coffee. When it cannot be immediately used, it should be kept in closed canisters, and not in paper or open jars.

In addition to the volatile oil, which is contained in roasted coffee in the proportion of about 1 part in 50,000, coffee contains **caffeine**, of which there is $\frac{3}{4}$ to 1 per cent.; and an

astringent acid, called caffeo-tannic or caffeic acid, which differs from ordinary **tannin** in that it does not blacken a solution of an iron salt. This acid is somewhat altered by roasting, but retains its astringent properties.

The chief adulteration of coffee is **Chicory**, which is thought by some to improve the coffee. It is generally harmless, though in some people it produces heartburn and diarrhœa. Chicory is prepared from the root of the wild endive, belonging to the same tribe as the lettuce and dandelion. It contains a volatile oil and a bitter principle, but nothing analogous to theine or caffeine. It is therefore of no utility as a stimulating or refreshing agent. Its presence can be detected by shaking a little of the suspected coffee in a wine-glassful of cold water. Coffee swims on the surface, and gives little or no colouration to the water; while chicory sinks, and gives a deep red tint.

The leaves of the coffee plant contain nearly as much theine as those of the tea plant, and are said to be preferred by the Sumatrans to the seeds. They are prepared by roasting in the same way as tea. When insufficiently roasted, they tend, like green tea, to produce sleeplessness.

The Preparation of Coffee ought to be effected as in the case of tea—by making an infusion and not a decoction, *i.e.*, by pouring boiling water on the coffee and allowing it to stand, but not continuing the boiling. Continuance of boiling dissipates the delicate aroma.

Inasmuch as coffee contains a much smaller percentage of theine than tea, more of the former must be used to obtain a beverage equally refreshing with tea. One ounce to a pint of boiling water is barely enough (Dr. V. Poore). The best plan is to make a strong infusion of the coffee, and mix this with an equal part of boiled milk. The coffee ought, if possible, to be freshly roasted. The Arabs seem to have little regard for the aroma, as they make a decoction of the unroasted seeds, and consume this with the grounds.

The colour of coffee is no guide to its strength. Many of the black coffees owe their colour to the caramel (burnt sugar) they contain. A mixture of coffee and chicory gives an infusion of higher specific gravity (1020–23) than pure coffee (1009–10), but is much more liable to upset the stomach.

Coffee has similar properties to tea, with some minor differences. (1) Like tea, it is restorative and sustaining in its action, but seems to act more quickly than tea, probably on account of the absence of tannin. (2) Unlike tea, it does not tend to produce perspiration, but rather a dry hot skin. (3) With some it is decidedly laxative; while tea, especially if badly made, has an opposite effect; but this is not always the case. (4) It seems to have a greater power of antagonising the effects of alcohol than tea; and besides this, is a valuable antidote, after the action of an emetic, in poisoning by opium or arsenic or alcohol.

The effect of coffee on digestion varies somewhat. As a rule, it is not so prone to disorder the digestion as tea, but this is not universally true, and in some persons it always produces biliousness. When taken in excess, it produces—besides indigestion—palpitation, restlessness, irritability, sleeplessness, and a condition of general nervous prostration; in fact, similar symptoms to those produced by a prolonged over-indulgence in tea.

It is curious, that while the consumption of tea is rapidly on the increase, that of coffee is steadily diminishing. This is partly owing to the greater expense of coffee—a larger quantity being required to form a good beverage; partly to the greater difficulty in preparing good coffee; and to some extent to the adulteration with chicory, dandelion, etc.

Cocoa.—Cocoa, or more properly cacao, is obtained from the seeds of the Theobroma Cacao—a native of the West Indies, Mexico, and the central parts of America. Its name Theobroma was given it by Linnæus, and means the "food of gods." The fruit is a large leathery capsule, having nearly the form of a cucumber. It contains from 25 to 30 seeds, each about the size of

an almond. Before using, these are roasted like coffee berries, and a peculiar aroma is developed in this process as in the case of coffee. The beans or seeds are then manufactured into three different products. (1) They are simply deprived of their husks and broken to pieces; this forms **Cocoa-Nibs.** (2) They are ground, husk and all, between hot rollers, into a paste, and mixed with starch and sugar; this forms **Cocoa.** (3) They are shelled and then ground into a paste, as in making cocoa; sugar and some seasoning, usually vanilla, being subsequently thoroughly mixed; this paste is **Chocolate.**

The purest form is the cocoa-nibs. When these are boiled in water, a brownish decoction is formed, with the fat as a scum at the top; this may be removed, and the decoction flavoured with milk and sugar. In this form, cocoa can be taken by invalids with weak digestion, who would be nauseated by the fat of ordinary cocoa or chocolate.

The shells or husks, which are separated from the beans before the preparation of chocolate or cocoa-nibs, contain theobromine; hence they yield on boiling a stimulant beverage, which may be used instead of tea or coffee, and possesses the advantage of being cheaper.

The best cocoa is prepared as above; but the lowest quality contains the husks of the beans, with hardly any of the beans in it; a somewhat better, though still inferior sort, is made from the smaller fragments of the nibs, and a good deal of husk. In some cases the cacao butter is removed during the process of preparation, and starch or sugar substituted. This form is less likely to disagree with dyspeptics than ordinary kinds of cocoa.

The usual way of preparing cocoa is to put a large tea-spoonful of the powder into a cup, mix it thoroughly with a little boiling water, and then fill up with water, and add sugar and milk to taste. A still more nutritious beverage is obtained if a larger amount of milk is employed. An equally stimulating and less heavy beverage is obtained by infusing the nibs, and removing the fat.

Chocolate is made into a beverage by scraping down the cake, and then mixing, as in the case of cocoa, with boiling water or boiling milk. It is taken on the continent as a thick paste; in England it is made more liquid.

Cocoa presents some striking resemblances to tea and coffee, and some points in which it is very different. The following table of the composition of the whole bean, as given by Johnstone, brings these out:—

Water ...	5
Starch, Gum, etc. ...	22
Gluten, etc. ...	20
Oil (Cacao-butter) ...	51
Theobromine ...	2
	100

It resembles tea and coffee in possessing an alkaloid, theobromine, which has like properties with theine; but differs in composition and mode of preparation for drinking. The starch, gluten, and oil render cocoa highly nutritive; and the fact that it is made into a decoction enables these substances to be taken in the liquid.

The action of the **Volatile Oil** (not the cacao-butter) developed during roasting, is probably similar to that of tea and coffee, though it is less in amount. The bitterness is greater than that of coffee, but the astringency less than in either tea or coffee.

The **Concrete Oil**, or fat of cocoa, forms about half its weight. It is white, and not apt to turn rancid, and possesses an agreeable flavour. The starch and gluten with the cacao-butter, render cocoa a most nutritious article of diet.

Theobromine is a white crystalline alkaloid, the exact analogue of caffeine or theine. The latter, in fact, is methyl-theobromine—that is, theobromine *plus* the theoretical group CH_2. Recently theobromine has been artificially converted into theine.

So rich in nutritious matter is cocoa, that it bears a close

resemblance to milk, the typical animal food. The resemblance and the difference are well shewn in the following table from Johnstone :—

	DRIED MILK.	DRIED COCOA BEAN.
Casein or Gluten...	35	21
Fat	24	51
Sugar or Starch, etc....	37	22
Mineral or Saline Matter... ...	4	4
Theobromine	—	2
	100	100

The presence of theobromine gives an exhilarating and stimulating influence to cocoa, which is not possessed by milk. The excess of fat in cocoa is liable to derange weak digestions : this is commonly obviated by abstracting some of it, and substituting sugar.

MINOR STIMULANTS.—The almost universal use of beverages containing theine, or some analogous principle, leads one to infer that they supply a generally felt want. It has been commonly supposed that they produce their supporting and exhilarating effect by diminishing tissue-waste, but we have given some facts throwing doubt on this conclusion. In moderate doses, they assist the assimilation of other foods, and probably increase respiratory processes. Their main influence, however, is on the nervous system; and their remarkable effect on this is, doubtless, the reason why they are so universally used. Theine-containing substances may be described as both sedative and exciting. They are sedative, in that they allay nervous irritability, and tend to "take the edge off" the disturbance caused by outward circumstances; and they are exciting, inasmuch as they are known to form an admirable antidote to the stupefying effects of opium or alcohol. The wakefulness from tea is an instance of the same

thing, while the allaying of sensations of cold and hunger by a cup of tea is an instance of the sedative effect.

In Brazil, **Guarana** (from *Paullinia sorbilis*) is used as a drink; it contains theine, the quantity of which is twice as much as in good black tea, and five times as much as in coffee. Like green tea, a cup of guarana infusion is sometimes extremely valuable in nervous headaches.

In Peru, the natives use the leaves of the **Coca** plant (*Erythroxylon coca*), which must be carefully distinguished from cocoa. It is chewed somewhat in the same way as the betel-nut. It contains two alkaloids—cocoaine and hygrine, as well as tannin. In its stimulant action it resembles tea and coffee.

The **Kola-nut** is used in some parts of Western Africa as a stimulant. It is about the size of a pigeon's egg, and has a bitter taste. The natives of Guinea generally take a piece of the seeds before each meal, and sometimes nibble it throughout the day.

Kava is prepared from the root of a kind of pepper. The natives of the Fiji islands commonly indulge in it. Its effects resemble those of coffee. In large doses, it destroys the power of walking, and may possibly produce impairment of vision.

The leaves of the *Ilex Paraguayense*, *Ilex Gongorrha*, and *Ilex Theezans* are made into the beverage commonly known as **Paraguay tea** or maté.

The leaves of the **Hydrangea Thunbergii** are made into a beverage, which is designated in Japan "the tea of heaven."

Among certain nations of Asia, the **Betel-nut** (from a palm called *Areca Catechu*) is chewed, after mixing small fragments with pepper and quick-lime, and rolling in a palm leaf. The saliva is tinged blood-red, and a narcotic effect is said to be produced.

The dried flowering tops of the **Indian Hemp** (*Cannabis Indica*) are smoked by the Malays and others, or made into a beverage, called haschisch, which produces a kind of intoxication, in which murder has often been committed (hence, *assassins* equals haschascheens).

The Kamtschatkans drink an infusion made from a fungus, known as the **Fly Agaric** (*Amanita Muscaria*); thus producing an intoxication similar to that from haschisch.

Opium in small doses is a stimulant, in large doses narcotic. The crude drug is sometimes taken, and less frequently the active principle, Morphia. It is frequently smoked, as well as taken internally. It is to be feared that secret opium taking is considerably increasing.

Tobacco may be conveniently mentioned here, though its usual effects are certainly not stimulant. It is smoked, chewed, or taken as snuff; when indulged in to excess it produces serious depression of the heart's action, with frequent intermittence. In moderate doses it is sedative as well as slightly laxative. Prolonged indulgence in tobacco has produced many cases of incomplete blindness (*tobacco amblyopia*), in some cases it comes on with much smaller doses, and in all cases is only curable by ceasing to smoke.

CHAPTER VIII.

FERMENTED DRINKS.

Properties of Alcohol.—Effects produced by moderate quantities of Alcohol.—Effects of Immoderate Quantities.—Circumstances Modifying the Action of Alcohol.—Is Alcohol Advisable as an Article of Diet?—The Varieties of Fermented Drinks.

Properties of Alcohol.—When a saccharine solution is subjected to the influence of warmth and moisture, and exposed to the air, it rapidly undergoes a process of **fermentation.** The most favourable temperature is about 70° Fahr. The ferment or agent exciting the change in the sugar is derived from the atmosphere; it is a minute fungus (torula cerevisiæ), the spores of which are constantly floating in the air. When once fermentation has started, exposure to the air is no longer necessary; the process continues in closed vessels. The essential change occurring in the vinous fermentation is that grape sugar ($C_6H_{12}O_6, H_2O$) becomes split up into alcohol (C_2H_5OH) and carbonic acid (CO_2). Thus—

$$C_6H_{12}O_6 = \begin{array}{l} \left.\begin{array}{l} C_2H_6O \\ C_2H_6O \end{array}\right\} \text{Two of alcohol.} \\ \left.\begin{array}{l} CO_2 \\ CO_2 \end{array}\right\} \text{Two of carbonic acid.} \end{array}$$

There are other fermentations allied to the vinous. Thus the **Acetous** fermentation results in the conversion of alcohol into vinegar, as in the souring of beer or wine. The **Lactic** fermentation leads to the conversion of milk-sugar into lactic acid, with consequent souring of the milk.

Putrefaction is a process allied to fermentation, occurring in more complex and nitrogenous bodies, and accompanied by the formation of various fœtid products.

Alcohol, or more correctly ethylic alcohol, is a colourless liquid, having a pleasant vinous odour, and evaporating rapidly on exposure to air. It burns with a bluish sootless flame, and is a capital solvent for resins and other substances. Absinthe is a strong spirit,

containing oil of wormwood in solution. Proof-spirit is a mixture of about equal parts of water and alcohol. The fermented drinks containing alcohol may be classed as (1) malt liquors, (2) wines, and (3) distilled spirits. The relative properties of these will be considered afterwards; in the next two sections will be considered the effects of diluted alcohol in whatever form it is taken.

Effects of Moderate Doses of Alcohol on the System.—In studying the physiological effects of alcohol, one has to guard against the fallacy that these are the same, only differing in degree, whatever the dose may be. The effects of large doses of alcohol are almost exactly the reverse of those produced by small doses. It will be necessary to define, therefore, what we mean by a moderate dose. By a moderate dose, we understand the amount of alcohol which can be taken without any alcohol being eliminated in the urine. Dr. Anstie found that 1½ ounces, that is three table-spoonsful, of absolute alcohol, taken in twenty-four hours, caused its appearance in the urine; and Dr. Parkes and Count Wollowicz obtained almost precisely the same result. Anything below some quantity between 1 and 1½ fluid ounces per day can be disposed of in the system, and is probably oxidised like ordinary foods.

It is important to know how much alcohol, in the form of alcoholic beverages, corresponds to this **maximum dose** of absolute alcohol. The stronger ales and porters contain 5 to 8 per cent. of alcohol. If 5 per cent., then 30 fluid ounces, or 1½ pints would contain 1½ fluid ounces of alcohol. The light French wines and Burgundies and Rhine wines brought to this country seldom contain less than 10 per cent. of alcohol; consequently, ¾ pint would contain 1½ ounces of alcohol. Ports and sherries, as sold here, contain 14 to 25 per cent. of alcohol; if 20 per cent., 7½ fluid ounces would contain 1½ ounces of alcohol. Many ports and sherries, however, contain 24 to 25 per cent. of alcohol; 6 ounces would, therefore, form a safer limit. Spirits contain 33 to 50 per cent.; if we suppose it to be 50, then 3 fluid ounces contain 1½ ounces of alcohol.

It will be understood, therefore, that in describing the effects of a moderate amount of alcohol on the system, we mean an amount below $1\frac{1}{2}$ ounces of absolute alcohol per day, freely diluted, and taken as a rule with meals.

1. **Effect on the Stomach.**—In very small quantities, alcohol seems to stimulate digestion in the same way as mustard. But like all other artificial helps to digestion, it is best avoided in the healthy condition.

2. The **Effect on the Liver** is similar to that on the stomach—a temporary redness and congestion being produced; this effect soon disappearing if the dose is small and well diluted. But in all cases where there is a tendency to biliousness, even small doses of alcohol are injurious.

3. The **Effect on the Lungs** is somewhat doubtful, carbonic acid having been stated by some to be increased and by others diminished.

4. The **Effect on the Heart and Blood-Vessels** is first to increase the force of the heart's action and the rapidity of the pulse. If the alcohol is taken undiluted and on an empty stomach, these effects are noticed, even before its absorption into the blood, owing to a stimulus being carried up to the medulla oblongata, and reflected thence. The stimulation of the heart is rapidly followed by a universal dilatation of the arterioles of the body, which diminishes the blood-pressure.

5. The **Effect on the Blood** is that its oxygen-carrying properties are diminished, even when only small quantities are taken. This effect is, however, more than compensated for by the increased rapidity of the circulation produced by alcohol; although each relay of blood contains less oxygen, the blood, being brought more frequently to each individual part of the body, supplies as much or more oxygen than in the unstimulated condition.

6. The **Effect on the Nervous System** varies. In persons unaccustomed to its effects, even small doses dull the power of thought and the rapidity of perception. In most cases, however,

it at first produces increased rapidity of thought and excites the imagination, though even here it makes it more difficult to keep to one train of thought. Dr. E. Smith's experiments show that it diminishes the acuteness of all the senses. Its influence, in dietetic doses, on the capacity for mental work, has just been made the subject of a curious investigation by Mr. A. A. Reade. He has collected the experience of some of our most noted men of letters, the results obtained being so opposite as to prevent any general conclusion being made. It is interesting to note that Mr. Gladstone finds his "glass or two of claret at luncheon, the same at dinner, with the addition of a glass of light port . . . especially necessary to him at the times of greatest intellectual exertion;" while Archdeacon Farrar believes, from his experience, that "work may be done more vigorously, and with less fatigue, without wine than with it." The probability is, that in small doses it has no great influence either way, and that much depends on the habits to which the individual has become accustomed.

7. The **Effect on the Muscular System** is never beneficial. Even when only small quantities are taken, the power of controlling delicate movements is slightly diminished. For persons engaged in laborious occupations, a small quantity does not produce much apparent effect, but where the quantity exceeds two fluid ounces per day the capacity for strong and sustained muscular work is manifestly lessened (Parkes). This effect is probably due partly to the dulling of the nervous system rendering the muscles less amenable to the will, and partly to the over-excitation of the heart causing palpitation and breathlessness.

8. The **Effect on the Metamorphosis of Tissues** is probably to diminish oxidation, on account of the diminution of oxygen in the blood, and thus to favour the deposit of fat in the tissues. The diminished oxidation is necessarily followed by diminished elimination; but the decrease when only small doses are taken is hardly appreciable.

9. The **Effect on the Temperature** is probably to produce a

slight lowering, but unless the dose is excessive, this is hardly appreciable. The resistance to excessive cold is diminished by even moderate doses of alcohol, still more by large doses. In the Arctic regions, this has been abundantly proved. It is well known there that indulgence in alcohol is almost certain death when the external cold is great. Dr. Hayes, surgeon of the Kane Expedition (1859), says that he will not only not use spirits, but will take no man accustomed to use them.

Effects of Immoderate Doses of Alcohol on the System.—Bearing in mind the definition given of a moderate dose, one is bound to admit that a large number of individuals exceed this amount daily, apparently without any very serious results. The system becomes habituated to large doses, and if the occupation is a laborious one, they are oxidised in the system. Such, however, are exceptional cases. In the majority of cases evil results are in the end certain to follow. And such evil results are by no means confined to those who indulge in very large quantities of alcohol at varying intervals. In fact these often escape comparatively free, while others who never take a quantity sufficient to incapacitate them for their work, are sowing the seeds of chronic and oft incurable disease. The labourer who has a drinking bout at intervals is thoroughly nauseated, and the condition of liver and stomach induced, enforces abstinence on him for a time sufficient to bring his organs back to a normal condition; while the city merchant who indulges more moderately, but whose organs are almost continuously saturated with alcohol, becomes gouty and prematurely old.

The **Stomach** may become acutely inflamed, when a large dose of alcohol is taken. The chronic irritation of alcohol, especially when taken apart from meals, causes atrophy of the walls of the stomach, and a change analogous to that in the liver.

The **Liver**, when alcohol is daily taken immoderately, becomes seriously diseased. In some cases it becomes large and fatty; in others the chronic irritation excites an overgrowth of fibrous tissue between the lobules of the liver, which, gradually shrinking, squeezes

the liver cells and causes them to atrophy, at the same time obstructing the small branches of the portal vein in the substance of the liver. The consequence of this obstruction is that all the organs from which the portal vein brings blood become overloaded with blood, which is not able to get easily through the liver, and vomiting of blood and dropsy of the abdomen occur at a later period.

The **Lungs** are irritated to a less extent by alcohol in large doses. The tendency to chronic bronchitis is increased, followed by emphysema, and sometimes an overgrowth of fibrous tissue (cirrhosis) like that in the liver occurs.

The **Heart and Blood-vessels** tend to become diseased, owing largely to the gouty condition of system developed.

The **Blood** has its oxidising power diminished. Corpulence is, consequently, a common result of alcoholism. There may also be fatty deposit in internal organs, such as the heart. This must not, however, be confounded with a much more serious condition—fatty *degeneration* of the heart, in which the substance of the muscular fibres becomes partially converted into fat, and which also is sometimes due to alcoholism.

The **Nervous System** is more prone to suffer in chronic alcoholism than any other part of the body, except perhaps the liver. The first effect of a large dose of alcohol is to stimulate the nervous system, as already described. This is followed by a dulling of the nervous faculties, which comes on rapidly in proportion to the amount taken. The phenomena of *intoxication* are unhappily too familiar to require description, mental incoherence and muscular inco-ordination (lack of control over the muscles) being the most prominent features.

When the dose of alcohol is still larger, a condition of profound unconsciousness is produced (*coma*), which may be difficult to distinguish from other forms of unconsciousness.

Delirium Tremens is another nervous condition, which may rarely follow a single debauch, but much more commonly affects

the chronic toper. In some cases the immediate exciting cause is a mental shock, or lack of food, or a surgical injury. Alcoholic subjects suffering from any acute disease are liable to this form of delirium, and their chance of recovery is greatly diminished.

Insanity of a more prolonged character than that characterising delirium tremens is an occasional result of alcoholism.

Besides the nervous diseases already named, a chronic thickening of the membranes covering the brain and spinal cord, gradually progressing and finally fatal, is often the consequence of prolonged alcoholic indulgence.

This does not complete the list of nervous diseases due to alcoholism. An unstable condition of the nervous system is produced, which is transmitted to the progeny. This may manifest itself in the form of epilepsy, or occasionally in other ways. A craving for alcohol is, unhappily, likewise transmitted; a temperate life is more difficult for the child of drunken parents than for others. The children of drunkards are very liable to scrofula and idiocy.

Various Degenerative Diseases are produced by alcohol. It has been well called by Dickinson the very "genius of degeneration." Such degenerations are by no means confined to the intemperate; they are seen in those who are of what would usually be considered moderate habits. The stomach, liver, lungs, and probably the kidneys, are the main organs to suffer in this way. It is probable that the effect on the kidneys only occurs when a gouty condition is developed. In all these cases there is an overgrowth of fibrous tissue, with atrophy of the proper gland structures.

Gout is the common nemesis of those indulging in alcoholic beverages, more especially wine and beer. It is due to the fact that urate of soda is largely formed in the body in the place of the more completely oxidised urea. This accumulates in the system and produces inflammation of the joints, and other evils—among them the gouty kidney, named above, which is always ultimately fatal. Rigid arteries are likewise commonly due to

alcoholism and gout. If one of these bursts in the brain, apoplexy results.

Longevity is diminished by immoderate indulgence in alcohol. Mr. Neison's statistics show that if a man becomes intemperate at 20 years of age, he shortens his life by nearly 30 years, and if at 30, by 22 years. The effect of moderate quantities of alcohol on longevity is much more difficult to decide. The statistics of the United Kingdom Temperance and General Provident Institution, are, perhaps, the most reliable on this point. It was found that in 23 years (1866-87), 3,937 deaths were expected, according to the calculations of the actuaries, among the section containing only total abstainers, but only 2,796 deaths took place; while in the general section, containing moderate drinkers, 6,114 deaths were expected, and 5,984 actually occurred. Thus, 29 per cent. less than the calculated number died among the teetotallers, while only 3 per cent. less than the calculated number died among the moderate drinkers.

These results, although valuable, must, however, be accepted with some degree of hesitation,—first, because the numbers are somewhat small, and, therefore, other factors may have caused the difference; and second, because although the second section was supposed to consist of moderate drinkers—and particular enquiries are always made on this point before insurance—it is by no means certain, in fact, it is very improbable, that a large portion of the moderate drinkers did not exceed $1\frac{1}{2}$ ounces of alcohol per day.

Factors Modifying the Effects of Alcohol.—1. **Age and Sex.**—There can be no doubt that, until adult life is reached, total abstinence from alcohol should be enforced. The delicate nervous system of children is easily disturbed by it, and it appears in some measure to retard growth. Another argument against giving alcohol before adult age is reached, is still more important. It is at this period of life that habits are chiefly formed, and a craving for alcohol may be insidiously produced, destined to have most baneful results.

Old people commonly have spirits given them ; as a rule, this is bad. Nothing stronger than light wines should be taken, except under medical advice.

Women, on account of their mobile nervous system, are much more easily affected by alcohol then men, and if they acquire the habit of excess, the hope of reformation is even less than with men.

2. **Exercise** has a most important influence in modifying the effects of alcohol. Those of sedentary occupations and living in towns, cannot oxidise as much as those engaged in active out-door work, and are consequently much more prone to suffer. A game-keeper in the Scotch Highlands may possibly live to a good age, spite of the fact that he consumes an amount of whiskey that would have sent a sedentary man to his grave in the course of a few years.

3. **The Condition of the Stomach** has also great influence. When the stomach is empty, alcohol produces at once a powerful reflex stimulation of the heart, and becomes quickly absorbed into the circulation. Thus intoxication may be produced by a quantity that would have had little effect if taken with a meal.

4. **The State of Concentration or Dilution** modifies greatly the action of alcohol, the local action on the stomach and the reflex stimulation being much greater when it is concentrated, and injurious effects being much more likely to occur.

5. **Cold and Heat** modify the action of alcohol. A smaller quantity of hot spirits and water will intoxicate than of cold; the heat stimulating the heart, and so making the absorption of the alcohol more rapid. A glass of hot spirits and water will often cause sleep, by drawing the blood towards the abdominal organs. The fact that persons, who have been drinking spirits in a warm room, on going out into the cold air become suddenly intoxicated, seems opposed to what has been already said. But probably this is due to the cold causing contraction of the arteries of the skin, and so driving more of the blood loaded with alcohol to the internal organs and the brain (Brunton).

6. **Mental Occupation** has some influence in modifying the

effects of alcohol. Topers have found that if they try to converse during their debauch—the conversation implying increased functional activity of the brain, and therefore a freer circulation of blood in it—intoxication occurs much more readily, than when the attention is not distracted.

7. **Disease** modifies greatly the effects of alcohol. In some diseases, as in inflammation of the lungs and in fevers, it can be given in large quantities without producing intoxication; and in these conditions it seems to diminish the excessive oxidation which is occurring, and to lower the temperature. In other diseases, especially gout and kidney disease, its use is nearly always followed by bad results.

THE ADVISABILITY OF ALCOHOL AS AN ARTICLE OF DIET IN HEALTH.—This is a question which it is very difficult to decide. There are two sets of facts to be dealt with—those obtained as the result of **Physiological** observations (see previous sections), and those which are the result of **Experience.** There can be no doubt that the former are much more reliable than the latter. Experience is very prone to give fallacious results, especially when questions of appetite are concerned. In making a trial of abstinence, the mistake has been commonly made of only prolonging the investigation for a few weeks, and then comparing results. Such a method is, however, very unfair, and is certain to lead to an unreliable conclusion.

The results of experience under certain conditions have, however, been so extensive, as to lead to valuable and reliable results. It has been abundantly proved that prolonged muscular work is best undergone during total abstinence from alcohol; and that the extremes of heat and cold and the exposure and exertions of marching armies, are best borne under similar conditions.

The artificial character of town life is commonly adduced as an argument for the moderate use of alcohol. In the case of healthy workers, this does not hold good; many of our hardest workers and thinkers take no alcohol.

The universality of the habit of taking stimulants is a curious

argument on the same side, though if the habit be bad, this can be no more reason for continuing it than can the prevalence of vice be an excuse for indulgence in it.

The two chief physiological points bearing on the advisability of alcohol as a part of one's daily diet are—its **food properties**, and its effect on the appetite and digestion.

It has been already stated that a quantity of alcohol under 1 or 1½ ounces may become oxidised in the system, and may thus form a source of heat. But in all probability, although it may be regarded as a food, it is a most inconvenient one, inasmuch as it diminishes the oxidation of other foods. It has been aptly compared in this respect to sulphur, which is an oxidisable material, but which, when it is burnt in a chimney, in which the soot is on fire, will put an end to the combustion of the latter. Its value as a food, under normal conditions, is practically nil.

Its **Effect on the Digestive Organs** is two-fold. First, the contact of the alcohol with the mucous membrane of the mouth and stomach, acts as a reflex nervous stimulus, which in moderation excites an increased flow of gastric juice. In cases of weak digestion, therefore, small doses of alcohol may, at times, be useful. The effect of alcohol on the food taken varies with its degree of dilution. Concentrated alcohol coagulates albumin, and so stops digestion; it is doubtful whether largely diluted alcohol has such an effect.

We cannot do better than quote the opinion of Dr. Parkes, the greatest authority on the dietetic use of alcohol, in connection with this subject. He says:—

"But what, now, should be the conclusion as to the use of alcohol in health after growth is completed? Admitting the impossibility of proving a small quantity to be hurtful, and at the same time acknowledging the dangers of excess, there arises an argument which seems to me somewhat in favour of total abstinence. No man can say when he has passed the boundary which divides safety from harm; he may call himself temperate, and yet may be daily taking a little more than his system can bear, and be

gradually causing some tissue to undergo slow degeneration. He may be safe, but he may be on the verge of danger.

"This uncertainty, coupled with the difficulty at present of saying what dietetic advantage is gained by using alcohol, seems to me rather to turn the scale in favour of total abstinence instead of moderate drinking. But if any one honestly tries, and finds he is better in health for a little alcohol, let him take it, but he should keep within the boundary line, viz., that 1½ ounces of pure or absolute alcohol in twenty-four hours form the limit of moderation. I do not then think he can do himself any harm."

THE VARIETIES OF FERMENTED DRINKS.—The three chief kinds of alcoholic beverages have already been named—malt liquors, wines, and ardent spirits. In addition, we may mention cider and perry, which are the fermented juices of apples and pears respectively; and koumiss, which the Tartars prepare by fermenting mare's milk, though it may also be made from the milk of other animals.

All **Beers, Ales,** and **Porters** are prepared from malt, which is the germinating grain of barley. The fermentation of the sugar in the barley produces alcohol, the amount of which varies in different cases. In small-beer it may be only 1½ per cent. of absolute alcohol; in stout 6 per cent.; in porter 5 per cent. or more; and in Burton ale, as high as 8½ per cent. The hop which is added to the fermenting barley, gives to beer its characteristic bitterness.

London Porter is coloured with black or roasted malt; **stout** is only a stronger form of porter. Bottled ales are generally stronger than those on draught, and being slightly effervescent, may agree better.

The effect of alcohol in beer is modified by the *hops*, which are liable to produce drowsiness. Beer has a marked tendency to produce obesity, more so than any other alcoholic beverage. Its influence in the production of gout is also very great. Probably its acidity is partly answerable for this, as gout is not produced as a rule by German beer.

Notwithstanding the apparent stoutness and strength of beer-drinkers, they are decidedly unhealthy. Even slight injuries are liable in them to produce serious or fatal results.

Wines are produced by the fermentation of the juice of the grape. The wine produced may be bottled after fermentation is complete, or at an earlier period; in the latter case, an effervescing wine is produced, such as the sparkling wines of the Rhine and the Moselle, or champagne. When the sugar is nearly all fermented a *dry* wine is obtained, of which Bordeaux and Burgundy, Hock and Moselle, are examples. If some sugar is left in the wine, it is a *sweet* wine.

The difference in colour between red and white wines is produced by allowing the juice in the former case to ferment in contact with the skins, from which the colouring matter is extracted by the alcohol produced. Both red and white wines may be obtained from either red or white grapes. From the skins also are extracted a salt of iron, and a peculiar form of tannin. Tartaric and acetic acids, and tartrate of potass, are present in varying quantities in wines; in old wines the tartrate separates as bi-tartrate of potass, forming with tannin and colouring matter, the "crust" of port and other wines. The "bouquet" of wines is due chiefly to certain volatile bodies, such as pelargonic ether. The proportion of alcohol in various wines has been already indicated. It is, however, a very varying constituent. Most of the wines sold in this country are brandied. It would be a most important reform, if it were required that all bottles of wine should be stamped with the proportion of alcohol they contain.

Wine, like beer, has a strong tendency to produce gout, especially the sweet and strong wines. It has not, however, the same tendency to induce obesity.

Spirits differ from the two last groups, to begin with, in the amount of alcohol they contain. Thus, ales contain from 1 to 10 per cent., wines from 8 to 20, and all kinds of spirits from 40 to 58 per cent. of alcohol. They differ in the absence of the bitter principle of beer and much of the salts and sugar and ether of wines. They

are all prepared by the distillation of some previously fermented liquor. **Brandy** ought to be made by the distillation of wine; and then contains, besides alcohol and water, small quantities of acetic, œnanthic, butyric, and valerianic ethers. But most of the brandy sold is simply made from spirit, by the addition of acetic ether, burnt sugar, etc.

Whiskey is prepared by the distillation of malt, and it contains fusel oil (amylic alcohol), in addition to ordinary alcohol. This is much more injurious to the health than ethylic alcohol. It seems probable that in old whiskey a good deal of the fusel oil becomes changed, probably into ether, and is then less injurious.

Gin and **Hollands** are obtained from barley, and flavoured with juniper berries and other materials. The oil of juniper stimulates the urinary excretion.

Rum is obtained by the distillation of molasses, and is usually kept for a long time in oak barrels. It is said thus to acquire more astringent matters than other spirits contain.

Prolonged indulgence in spirits produces the various organic diseases already described, and owing to the greater degree of concentration they are more harmful than beers or wines. They differ from wines and beers also in not tending to produce gout, and from beer in not leading to obesity. Gout is almost unknown in Scotland among the class of people who commonly drink large quantities of whiskey.

CHAPTER IX.

WATER.

The Uses of Water.—The Quantity of Water Required.—Sources of Water Supply.—Rain-water, Upland Surface, Spring, Well, and River Waters.—Their Relative Merits.

Uses of Water.—Water is a prime necessity of life. In its absence life can only exist in lowly organised beings, and in them only in a dormant state. From a hygienic point of view, the uses of water are four-fold:—(1) It is an essential part of our food,

not only serving to build up the tissues of the body (of which 111 lbs. out of 154 lbs. consist of water), but also preserving the fluidity of the blood and aiding excretion of effete matters. (2) It is necessary for **personal cleanliness**, of which the importance can scarcely be exaggerated. (3) **In the household** it is essential for cooking, as well as for washing the house, the linen, and various utensils. (4) By **the community at large** it is required for water-closets and sewers, for public baths, for cleansing the streets, and for horses and other domestic animals, as well as in many manufacturing processes. It is obvious that the water to be used for domestic and general purposes, need not be so pure as that for drinking purposes. Hence, a double supply was proposed for London in 1878, by the Metropolitan Board of Works—the present river supply for general purposes, and a deep chalk-well supply for drinking purposes. The scheme, however, rightly fell through, because of the expense of a double source of supply, and the danger that the impure water would, through carelessness or ignorance, be often used for drinking purposes, when it happened to be nearest at hand.

Quantity of Water Required.—The quantity of water required for all purposes has been variously stated by different authorities. The quantity required for drinking purposes is found to bear a relation to the weight of the individual, being nearly half an ounce for every pound weight, or $1\frac{1}{2}$ gills for every stone weight. Thus, a man weighing 150 lbs. would require $3\frac{3}{4}$ pints. Of this water, about one-third is taken in the food; the remainder, averaging $2\frac{1}{2}$ pints, being required as drink. If we add the water required for other purposes, according to Dr. de Chaumont, 1 gallon is required for drinking and cooking, 2 gallons (not including a bath) for personal cleanliness, 3 gallons for a share of utensil and house washing, 3 gallons for clothes washing; and if a bath be used, $2\frac{1}{2}$—3 gallons more; making a total of 12 gallons, to which 5 gallons must be added if there is a water-closet.

In hot summer weather the consumption is about 20 per cent. above the average of the year; and frost often increases the amount 30—40 per cent. above the average, owing to the bursting of pipes, or the loss from taps left open to prevent bursting.

In the army, 17 gallons is the quantity allowed for each individual. Water companies usually reckon 30—60 gallons, to allow for the water required in drainage and manufactories, and for waste. Professor Rankine estimates the amount required for all purposes as 19—27½ gallons per head per day, or an average of 22 gallons. In large houses, where baths are freely used, often as much as 70 gallons per head is used. In London, with an imperfect intermittent supply, the consumption is 32½ gallons per head daily, of which 7—7½ gallons is used for other than domestic purposes. The following is Dr. Parkes' estimate of the daily allowance for all purposes :—

	GALLONS PER HEAD OF POPULATION.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

It has been proposed to put a water-meter to each house, so that the rate may be in proportion to the amount of water used. This has actually been tried in some American towns; but the plan is objectionable for two reasons: 1st—Because it tends to restrict the necessary use of water for purposes of cleanliness. A scant supply of water is always followed by uncleanliness of house

and person, with its consequent diseases; at the same time drains are not properly flushed, and become, practically, long cesspools. 2nd—The primary expense of the meter, and of its maintenance, as well as of the necessary inspections and book-keeping, have caused it to defeat its own ends.

Sources of Water Supply.—All our drinking water is obtained for us, in the first instance, by a natural process of distillation on a large scale. The sun, acting the part of a powerful furnace, is constantly causing evaporation from sea and land. The vapor produced, being condensed by a lower temperature, returns to the earth as snow, dew, or rain. All these natural products have been at times utilised as sources of drinking water.

1. **Dew** has not often been employed as a source of drinking water; but this has occasionally been done at sea, when better sources were not available, by hanging out fleeces of wool at night and wringing them out in the morning. A much better plan is—

2. The **Distillation of Sea-water.** The water is evaporated in a special apparatus and the vapor collected, rejecting the first part which comes over, as this is always impure. Distilled water is very "flat" in taste, owing to its containing no dissolved gases. It can be aërated by letting it drop a considerable distance from one cask into another through small openings in the upper one, and by filtration through charcoal afterwards. Non-aërated water is not so easily absorbed into the system as ordinary water, and occasionally causes illness.

3. The utility of **Melted Snow and Ice** is obviously very limited. Moreover, its use is not free from danger, in consequence of the liability to contamination by excreta and other organic matters derived from dwelling-houses. The prevalence of cholera in Russia is an illustration of this fact.

4. **Rain-water** is a much more important source of water supply, and after passing through the soil it constitutes the chief part of the water we drink. The term, however, is usually restricted to the water collected immediately after its descent from

roofs, etc. Its purity depends on three conditions—the character of the air it passes through, the cleanliness of and absence of lead from the channels through which it runs, and the condition of the water-butts in which it is collected. Rain-water is soft; in fact, too soft to be pleasant to the palate. In passing through the air, it carries with it a certain proportion of its constituents; in towns, especially ammonia, soot, etc.; near the sea, it generally contains some salt; and being soft and containing oxygen from the air, it dissolves an appreciable amount of lead from roofs or gutters.

According to Dr. A. Smith, if it were possible to collect rain from the clouds, it would require filtering through the soil before being fit for drink. A certain amount of mineral salts and free aëration are requisite in order that water may be palatable.

The Rivers Pollution Commissioners, in their exhaustive examination of various kinds of water, found that out of eight samples of stored rain-water only one was fit to drink. They came to the conclusion that rain-water, collected from the roofs of houses and stored in underground tanks, is "often polluted to a dangerous extent by excrementitious matters, and is rarely of sufficiently good quality to be used for domestic purposes with safety." Also, that in Great Britain, and more particularly in England, we shall "look in vain to the atmosphere for a supply of water pure enough for dietetic purposes."

The use of rain-water for drinking purposes is only justifiable in isolated country houses where no better source is available; and under these circumstances the greatest care should be taken to prevent contamination with lead or organic impurities.

The amount of water obtainable from rain in any place can easily be estimated, if the amount of rainfall and the area of the receiving surface are known. The average annual rainfall in this country is 30 inches, varying from 20 inches on the east coast to 70 or 80 in the mountainous districts of Wales. In exceptional cases, as in the Lake District, as much as 200 inches have been recorded.

Suppose the rainfall to be 20 inches per annum, and the area of the receiving surface 500 square feet. Multiply the area by 144, to bring it into square inches, and this by the rainfall, and the product gives the number of cubic inches of rain which fall on the receiving area in a year. One cubic foot, or 1,728 cubic inches, of water being equivalent to 6·23 gallons, the number of gallons of water can be easily calculated. To calculate the receiving surface of the roof of a house, do not take into account the slope of the roof, but merely ascertain the area of the flat space actually covered by the roof. This may be done roughly by calculating the area of all the rooms on the ground floor, and allowing an additional amount for the space occupied by the walls. It has been estimated that, even if a rain-water supply for towns were desirable, the amount collected from the roofs of houses would scarcely average two gallons per person daily—assuming the average rainfall to be 20 inches, and that there was a roof area of 60 square feet for each individual.

5. **Upland Surface Water** is the water collected in hilly districts, as on moorlands, at the head of a river. By its utilisation for drinking purposes, the sources of water for the river are interfered with, and mill-owners and others lower down the stream might have cause for complaint. Any water company using such a source is, therefore, always bound to run into the stream a quantity of water equal to a third of the available rainfall. The limited and regular supply thus furnished to the stream is found to be a practical advantage, as its flow is equalised, and the violence of floods mitigated. The mode in which upland surface water is utilised is as follows :—

The water from the surrounding hills is collected at the bottom of a valley, in an artificial, strongly-constructed lake; or in a natural lake, as in the case of Loch Katrine (from which Glasgow is now supplied). The danger of the bursting of the reservoir (as in the case of Sheffield) has been urged against this mode of supply, but, with good engineering, this danger is very small.

Upland surface water is nearly always soft. Its use is much more economical than that of hard water. It may be brownish, from the presence of peat, but this is not objectionable, so far as health is concerned.

6. **Springs** supply water which, originally derived from rain-water, has percolated through the soil until it reaches some impervious stratum, and has then run along this, forming underground reservoirs, until it is forced up at some considerable distance by the pressure of its surroundings. The tendency is for the supply of spring-water to fail when most required—in dry and hot weather; it is important, therefore, to estimate the available supply from a spring in summer time, rather than in winter. In its passage underground, water (owing partly to the carbonic acid it has obtained from the air, and from decomposing vegetable matter in the soil), is able to dissolve small quantities of chalk, sulphate of lime and of magnesium, and traces of oxide of iron, aluminium oxide, and silica. Spring-water possesses an equable temperature, generally about 50° Fahr., while impounded or river water is always warm when wanted cool, and cool when wanted warm. The natural filtration to which spring-water has been subjected renders it aërated, and free from all impurities except mineral impurities; while, according to Voelcker, a competent authority, artificial filtration makes water flat. With regard to rain-water, he asserts, "the more you filter, the flatter it becomes."

7. **Wells** may form the best or worst sources of water-supply, according to their depth. There are two kinds—*surface wells* and *deep or Artesian wells.*

Surface Wells are such as do not descend further than 15 or 20 feet. They catch the subsoil or ground-water, which percolates into them from the surrounding soil, and the character of the water they receive will therefore vary with the nature of their surroundings. If there is a cesspool near, this may simply drain into the well; and it is often found that all the soakage from a considerable distance finds its way into the well. In villages and isolated places these

surface wells are much oftener seen than in towns, and are a fertile source of disease. Commonly, one hole is dug in the garden for a well, and another for a cesspool, while there is possibly a farm-yard near at hand—the soakage from the cesspool and farm-yard being drained into the well. A surface well, if allowed at all, ought to be in the middle of a field, remote from the house and its annexa, in a spot where soakage from sewage is impossible. In any case, surface wells not uncommonly dry up in summer time, owing to their being dependent on the subsoil water for their supply.

Deep Wells are made by digging an ordinary surface well, and lining it with brickwork, thoroughly set in cement, so that the subsoil water cannot enter it; and then boring from the bottom down through the subjacent rock until a water-bearing stratum is reached. Where the water is retained under pressure, deep wells are known as **Artesian Wells.** Such Artesian wells have been sunk in London, which has a clay and gravel soil over chalk rocks. Rain, falling on the chalk hills which lie to the south and north of London, percolates through the chalk downwards, and then laterally, until it lies in the concave London basin. Here the clay stratum above it prevents its escape upwards; and, being confined under considerable pressure, it rises to the surface, or into an ordinary well, when the clay is tapped.

As an example of the strata passed through in an Artesian boring, the Artesian well bored at Meux' brewery, in Tottenham Court Road, is very interesting. The depth of this well is 1,144½ feet, which is distributed among the different strata, from above downwards, as follows:—

Gravel	22 feet.
London Clay	63½ ,,
Woolwich and Reading Beds (Sands and Clay) ...	51 ,,
Thanet Sands...	21 ,,
Chalk	655 ,,
Upper Green-Sand	28 ,,
Gault	160 ,,
Lower Green-sand	64 ,,
Devonian	80 ,,

It was hoped that water would be found in the beds beneath the gault, which come to the surface at Goldstone, in Surrey, and are highly charged with water. But in this boring the water-bearing strata were not found, to the great disappointment of all concerned, and the boring had to be continued to the two deepest strata in the above list, which have within the last few weeks been pronounced by Professor Judd to be Oolitic beds.

The deepest Artesian wells are at Grenelle, in Paris (1,800 feet), and at Kissingen (1,878 feet). In the sinking of a deep well, it is well to remember that it may affect and exhaust all the neighbouring shallow wells for two or three miles, as well as all the cesspools. The danger of contamination from the latter is only present when the upper part of the well is not properly made.

For country places deep-well water is much preferable to water from streams, as streams are very liable to be contaminated by the sewage of houses higher up in their course, or even by that of others close by. A good well should be at least thirty feet deep—preferably fifty feet; and there ought to be no drain or cesspool within at least thirty yards, though it is doubtful if this distance is a sufficient protection in all cases. The direction of flow of the underground water is of greater importance than the actual distance of the well from the cesspool, etc. Pumping greatly increases the extent of soil which drains into a well.

An excellent plan to obtain water for villages, in a gravelly soil, is to sink a Norton's Abyssinian tube well for fifty or sixty feet. It is unfortunate that, in the present condition of the law, no compulsion can be brought to bear upon the landlord to supply wholesome water to his houses.

In towns it is, as a rule, preferable to trust to the public water supplied, rather than to any private well.

The water is obtained from a well by a *pump* or a *draw-well*. The former is by far the best plan. The use of a bucket is laborious and tedious, and necessitates opening the well every time water is wanted, thus leading to danger of animal matter or filth getting in.

8. **Rivers** and running streams originate in upland surface water or springs, and their water should be of the same quality. Unfortunately, they acquire a large amount of impurities in their course. Adjacent towns nearly always pour their sewage into them; even where this is not the case, sewage of villages or isolated houses suffices to poison the water. *Figure 1* illustrates the pollution of a mountain stream by the defective drains and overflow from cesspools (shown by dotted lines) of a country house. The house is supplied with water close to the point where the soakage from its sewage pollutes the water, and a small village is supplied with water at a lower point of the stream.

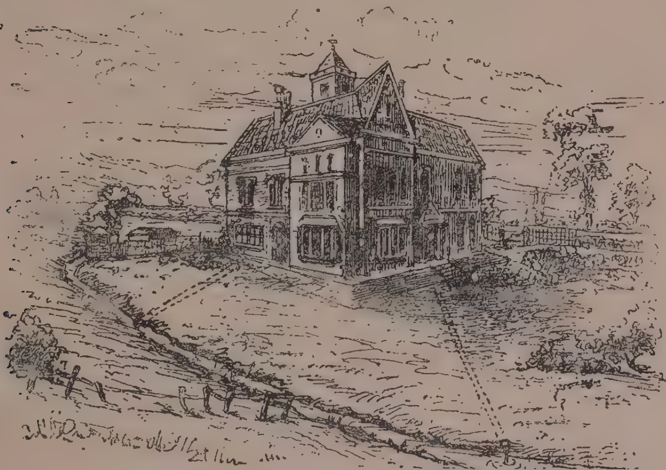


FIG. 1.

Mountain stream, affording a supply to a country-house, and, at a lower point, to a small village. Defective drains and overflow from cesspools (shown by dotted lines) polluting the stream.

If no animal contamination is present in a river, it forms an admirable source of water-supply; being running water, it is always well aërated, and is not usually so hard as spring-water.

Even if sewage has entered a river, it is asserted by some that it

remains a safe source of water-supply, after passage through filtering beds. This is evidently, however, acting on a wrong principle; far better to start with a pure supply than to use one which requires purifying. On the other hand, it is urged that the sewage entering into a river is got rid of in three ways.

1st.—By *subsidence*, the organic matter settling to the bottom.

2nd.—By the influence of *water-plants*, which assimilate ammonia, nitrates, etc., and give out nascent oxygen.

3rd.—*Oxidation.* Doubtless a large amount of the nitrogenous matter does become oxidised in its course down a river, and in this condition is harmless. It is doubtful, however, whether the living and active germs of disease become so oxidised. In one case, the contagion of cholera was carried 15—20 miles, by the River Don, from Sheffield to Doncaster. But if this is possible, it is strange that in London typhoid fever is not constantly epidemic; inasmuch as it is chiefly supplied with water (filtered sewage water we may call it), which has received the sewage from a large population living in towns and villages along the course of the Thames above the Companies' intake. There can be no doubt that typhoid fever is always more or less prevalent in these parts of the Thames valley.

Messrs. Odling and Tidy support the view that the supply of river-water to towns, even below the points where large populations have thrown in their sewage, is justifiable and safe, after thorough filtration. Messrs. Frankland and Voelcker oppose this view; and Dr. Frankland concludes, from numerous experiments, that "no river in the United Kingdom is long enough to effect the destruction of sewage by oxidation;" while Dr. A. Hill says that probably living matter does not get oxidised by flowing down a river, any more than a fish does in a similar course.

Judging by several Parliamentary decisions, the general concensus of opinion is against a river supply below a point at which any sewage has been received. In the case of the Durham, Cheltenham,

and Stockton Water Bills, this point has been raised, and decided in the House of Lords in every instance against the river supply.

Seven out of eight of the water companies, by which London is supplied, derive their water from the Thames and Lea—the exception being the Kent Water Company, which supplies water from deep chalk wells. In each of the seven cases, the intake of water is at a point below where sewage enters the river; and there can be no doubt that, had these companies *now* to apply for the necessary powers, their bills would be rejected by the Legislature.

In regard to the comparative merits of the various waters described, it will be useful to give here the classification made by the Rivers Pollution Commissioners in their sixth report:—

Wholesome	1. Spring Water	*Very palatable.*
	2. Deep-well Water	
	3. Upland Surface Water ...	*Moderately palatable.*
Suspicious	4. Stored Rain Water ...	
	5. Surface Water from Cultivated Land	*Palatable.*
Dangerous	6. River Water to which Sewage gains access ...	
	7. Shallow-well Water ...	

The geological formation of the soil has a great influence in rendering water palatable, colourless, and wholesome by percolation.

The following strata are said by the Commissioners to be the most efficient:—(1) Chalk, (2) oolite, (3) greensand, (4) Hastings sand, (5) new red and conglomerate sandstone.

CHAPTER X.

THE STORAGE AND DELIVERY OF WATER.

Relation of Water-supply to Rainfall and Character of Soil.—Construction of Reservoirs and Conduits.—Cisterns.—Intermittent and Constant Systems of Supply.

The methods of storing and delivering water will vary with its source. In rural districts, deep wells and springs are the best sources of supply; but in large towns they are found to be insuffi-

cient for the wants of a rapidly-increasing population; and they can only be multiplied in a given district within certain limits, as every well drains a large surrounding area. In the Bootle well, at Liverpool, which had 16 bore-holes—some of them 600 feet deep—it was found that, while the supply, when they were all open, was 1,127,920 gallons per day, it was only diminished to 921,192 gallons when they were all plugged but one (Wilson). The supply from surface wells in gravel or sand beds or in chalk districts is liable to fail in seasons of drought; but deep wells in oolite or chalk formations, and in the new red sandstone, generally yield a constant and abundant supply.

In towns, water is usually supplied by private companies, relieving the individual from responsibility in the matter. In some towns, like Manchester, the supply is under the control of the Corporation, and this is found to work advantageously, both as regards purity of water and lowness of rates.

When the water is supplied from upland surfaces, springs, or small streams, **a collecting reservoir** is required. This is generally a natural valley below the level of the source of supply, but of sufficient elevation above the place supplied to allow the water to be distributed by gravity, without any pumping apparatus. The reservoir should be large enough to hold five or six months' supply, and its embankment should be perfectly water-tight, and of great strength.

When water is collected from upland surfaces, it is important to know the amount of rainfall to be reckoned on. If we know the area of the surface which drains towards the reservoir, and the average rainfall, the *total* rainfall is easily calculated. This will, however, differ greatly from the *available* rainfall, owing to the losses from penetration into the ground, evaporation, and other causes. The amount lost will vary, according to the season, from one-half to seven-eighths of the total rainfall. In clay districts very little water sinks into the soil; in limestone, as much as 20 per cent.; in chalk districts, 42 per cent.; and in

loose, gravelly, or sandy districts, as much as 90 to 96 per cent. (Wilson). The amount of infiltration of the chief water-bearing strata surrounding London varies from 48 to 60 per cent. (Prestwich). The amount of infiltration will be less when the ground is steep and the rainfall rapid, and usually less in winter than summer.

Water collected near its actual place of fall, and from uncultivated districts, is always purer than that collected further from its source, and from cultivated land.

From the collecting or impounding reservoir, water is carried by the aqueduct or discharging pipe either directly into the service-pipes, or when the pressure is too great, into a second **service-reservoir**, resembling the impounding reservoir in general structure, and capable of holding a few days' supply.

This must be on high ground, above the level of the highest houses to which water has to be supplied, as water cannot rise above its own level. When this cannot be arranged, the water must be pumped into tanks at a higher level, and distributed from them.

The greatest hourly demand for water being double the average hourly demand, the main conduits supplying a town must have double the discharging power that would be required, supposing the demand were uniform. The first requisite of a supply of water is that it should be abundant, and sufficient in amount for any extra strain on its capacities. Water ought to be laid on to every house, and to at least two floors of the house. Anything preventing free access to water, militates against cleanliness.

Cast-iron is the most serviceable material used in the construction of the main water-pipes; it is coated with pitch, or Dr. Angus Smith's varnish, or with magnetic oxide of iron (Barff). The service-pipes to each house are generally made of lead, and the ease with which this material can be bent and curved, and carried to the different floors of a house, makes its use very convenient. Another reason urged by the water companies on behalf of lead-pipes, is the facility with which they can be obliterated in case

of bursting, and so any waste of water and flooding of the house prevented. Some kinds of water, unfortunately, act on and dissolve lead; this is especially true of soft waters and those containing organic matter. Shallow wells, being very liable to organic pollution, ought never to have the supply-pipe of their pumps made of lead. With hard waters, lead pipes may generally be used safely. When the quality of the water renders lead pipes objectionable, the use of iron, tin, zinc, tinned copper, earthenware, gutta-percha, and other materials, has been suggested. Of these, cast and wrought-iron pipes are the most serviceable, or pipes composed of an inner lining of block-tin and an outer of lead, so united as to be inseparable by any amount of twisting. According to Rawlinson, "supply-pipes of wrought-iron are cheaper, stronger, and more easily fitted than service-pipes of lead;" but it is urged against them by Parry, that with soft water they become choked by rust in a few years. Cast-iron pipes are rusted less easily than wrought-iron.

When the water-supply is from a river, filtering beds are needed, in addition to the parts of a water-service hitherto described. Moreover, since the river is usually at a low level, the water, after passing through the filtering beds, requires to be pumped into raised tanks, from which it is delivered.

In laying down water-pipes, in the streets and to houses, it is very important to make the distance between them and all drains and gas-pipes as great as possible. There is a tendency for suction of gases or liquids to occur into leaky pipes, even though these contain water, and still more when they are empty; and this forms an occasional mode of origin of disease.

The pipes bringing the water to a house may be kept constantly filled with water, or only for a limited time once or twice a day. The intermittent system of supply necessitates the provision of cisterns or water-tanks, in which water can be stored in the intervals of flow of water.

CISTERNS.—Cisterns for the supply of potable water may be

made of iron, slate, stone, glass, glazed earthenware, or brick lined with Portland cement. Other materials have been used, as timber, lead, and zinc. *Timber* is inadvisable, as it easily rots; *lead* is very objectionable, owing to the solvent action of the water on it. If on entering a house, there is found to be a lead cistern coated over with white carbonate of lead, it is inadvisable to wash it out periodically like other cisterns, as part of the coating will be disturbed and new lead exposed to the action of the water. *Zinc* is also acted on occasionally by water; but as it does not produce severe symptoms like those from lead, it may be used. According to Corfield, *galvanized iron* (that is, iron coated with a thin layer of zinc) is the best material for cisterns. Iron cisterns soon rust; but this may be prevented by giving them a coating of boiled linseed oil before they leave the foundry. *Stone cisterns* are too heavy for use, except in basements. *Slate cisterns* are good, but are apt to leak; the points of leakage are not uncommonly smeared with red lead, which is attacked by the water, and thus lead poisoning results. If the slate is set in good cement (not mortar, as this makes the water hard), it is perhaps the best of all materials for a cistern.

Every cistern should have a *well-fitting lid*, always kept closed; otherwise, not only dust gets into the water and noxious gases, but also decomposing vegetable matters, and even dead cats, birds, etc.

The cistern should be *easy of access*. If it is indoors, the cistern room should be well ventilated; and in any case the cistern should be periodically visited and cleaned out. When the cistern is full, a ball-tap prevents any further flow of water and if this does not act properly, an overflow pipe carries off the excess of water.

Cisterns badly arranged or neglected are a common source of disease. It is essential that (1) the *overflow pipe* should not pass into any part of the water-closet apparatus or the soil-pipe, or into the supply pipe to the water-closet, as it is seen to do in *Fig. 2*.

Where the overflow-pipe joins the soil-pipe below the syphon of the water-closet, sewer gas mounts directly into the cistern and is absorbed by the water; where it is joined to the trap of the syphon, on the side nearest the water-closet pan, only the offensive gases from the water-closet can, as a rule, mount into the cistern.

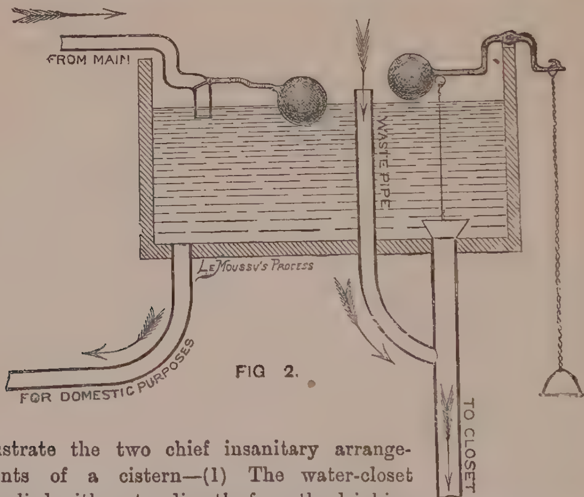


FIG 2.

To illustrate the two chief insanitary arrangements of a cistern—(1) The water-closet supplied with water directly from the drinking water cistern; and (2) the waste or overflow-pipe opening into the supply pipe to the water-closet, instead of into the open air.

(2) *No water-closet* ought to be supplied from the same cistern as supplies drinking water, as the pipe leading down to the closet often carries closet air to the cistern (*see Figure 2*). A small cistern or service-box should be provided for each closet.

With a constant supply of water, cisterns are only required for water-closets and hot-water apparatus, and possibly occasionally during repairs.

Constant and Intermittent Services.—With an intermittent service of water, during the intervals of supply, water is only obtainable from cisterns, water-butts, etc. The objections against this system are that—(1) The cisterns required are expensive,

and liable to get out of order and become foul. (2) Their overflow pipes commonly communicate with the soil pipe or some other part of the drainage, instead of opening into the external air. (3) Putrid gases, from neighbouring stench-pipes or other parts of the drainage system, are liable to be absorbed by the stagnant water in the cistern. (4) The chief objection to an intermittent supply is that, during the intervals in which the water-pipes are empty, foul air and liquids from the contiguous soil and drains are liable to be sucked through imperfect joints into the pipes. (5) In case of fire, the supply of water in the cistern is soon exhausted, and no more is obtainable until the turncock is found; thus there is often delay at the most important time. The importance of this evil is shown by the great reduction in insurance rates in Manchester, Liverpool, and other places, on the substitution of a constant for an intermittent service.

Many of these objections to the intermittent service are removable; it may be so arranged that there is no possibility of sewage or other contamination, but the best constructed apparatus is apt at some time to fail.

The only objectors to the constant service are the Water Companies. They urge that the fittings required for this system are expensive and liable to be stolen; and that, when through carelessness or accident, taps are left open or pipes burst, the waste of water is much greater than with a cistern supply. These objections have not been found to hold good where there is a well regulated and properly inspected constant supply. The increased waste, with a constant supply, only occurs where it is adopted with the same fittings and pipes as were used for the intermittent supply. But where the best screw taps and fittings are provided, and judicious regulations for preventing waste are enforced, the consumption of water is less than with an intermittent supply.

One valuable point in the constant system is that, in order to aid inspection and the detection of waste, the waste-pipe is not allowed to open into any part of the drainage; but, under the

name of a "warning pipe," is placed where the escape can be seen. Thus the possibility of sewer-gas being conducted back into houses through overflow pipes is avoided.

Occasionally, with a constant supply, there is not sufficient pressure to supply the upper stories of houses situated on a high level. In these cases, high level cisterns are required, provided with "warning pipes," ending in the open air.

The Advantages of the Constant Service may be thus summarised :—

(1) Owing to the absence of cisterns, the risks connected with stagnant water, and with improper ending of over-flow pipes, are obviated.

(2) The risk of suction into the pipes of external contaminations is reduced to a minimum, since the pipes are never empty.

(3) The pipes are less liable to rust. Air, in the presence of a little moisture, causes rapid corrosion.

(4) There is an abundant supply of water in case of fire.

Of course, when there is a temporary stoppage of supply, as for repairs, some of the dangers incurred by an intermittent supply will arise.

CHAPTER XI.

IMPURITIES OF WATER.

Properties of Pure Water.—Gaseous Impurities.—Mineral Impurities.—Hardness of Water.—Organic Impurities of Water.—Danger of Impurity not in Proportion to its Amount.

Properties of Water.—When pure, water is **colourless**, or bluish when seen in large quantity. It should be quite **inodorous.** If, after keeping it for some time in a perfectly clean vessel, a smell (however slight) of sulphuretted hydrogen is developed, the water is certainly bad. Its **taste** should be pleasant and sparkling from the atmospheric gases dissolved in it. Bitterness generally indicates the presence of sulphate of magnesium (Epsom salts). Saltness is always a suspicious property, except in

water obtained in the neighbourhood of salt mines or brine springs, or near the sea. It should be soft to the touch, and should dissolve soap easily. It should be bright and clear, and contain no suspended matters. Clear water is not necessarily pure, but turbid water is always to be rejected; the only exception being the brownish-tinged water from moors, which is not hurtful. In all other cases, printed matter should be legible through at least 18 inches of water. Thoroughly dissolved organic matter is less dangerous than suspended; the turbidity of water is therefore of great importance. But water may be bright and sparkling and apparently perfectly clear, when it is a deadly poison. The most important of the physical properties of water in regard to health, are the absence of smell and turbidity, and these can be ascertained by even the most inexperienced. The chemical tests for the more important impurities will be mentioned later.

The impurities of water may be classed under four heads—gaseous, mineral, vegetable, and animal.

The gases ordinarily present in water cannot properly be regarded as impurities, inasmuch as they are always present, and greatly increase its palatableness. The dissolved nitrogen and oxygen bear to each other the proportion 1·42 to 1; where sewage contamination occurs, it is probable that the oxygen would be diminished, owing to oxidation of the organic matter; and it has even been proposed to determine the presence of sewage by the absence of oxygen.

The amount of carbonic acid gas in water varies greatly. Impure water from churchyards is often clear, and sparkling from carbonic acid. Such water begins to stink after being kept for a few days. Fetid gases are occasionally absorbed by the water in cisterns, when there is a connection between the overflow-pipe of the cistern and the water-closet, or when the ventilating shaft from the soil-pipe has its open end near the cistern.

Mineral Impurities.—Mineral impurities are dissolved by water in its course through the soil, and so will vary with the

character of the latter. 1. The water obtained from *granitic* formations contains very little mineral matter, often not more than two to six grains per gallon. *Clay slate water* is also generally very pure, as is the water from hard *trap rocks.* 2. The water from *millstone grit* and *hard oolite* is very pure, often containing only four to eight grains per gallon, chiefly calcium and magnesium sulphate and carbonate. 3. *Soft sand-rock waters* usually contain thirty to eighty grains per gallon of sodium salts, with a little lime and magnesia. 4. *Loose sand and gravel waters* vary greatly. They may be almost free from mineral matter, or the solids may be more than seventy grains per gallon, including much organic matter. 5. Waters from the *lias clays* vary somewhat, but commonly contain a large quantity of calcium and magnesium sulphates. 6. *Chalk waters* generally contain from seven to twenty grains of calcium carbonate, with smaller quantities of other salts. 7. *Limestone and magnesian limestone waters* differ from the last, in containing more calcium sulphate and less calcium carbonate, as well as much magnesium sulphate and carbonate in the dolomite districts. 8. *Selenitic waters* contain calcium sulphate in considerable quantities. 9. *Clay waters* usually possess the characters of surface wells, and are objectionable. 10. *Alluvial waters* generally contain a large amount of various salts, including the various calcium, magnesium, and sodium salts. 11. *Artesian well water* varies greatly in composition. It may contain a large amount of sodium and potassium salts, or a small quantity of iron, or calcium salts. (Parkes: Manual of Practical Hygiene.)

It will be necessary to discuss the various mineral impurities in detail. The commonest and most important salt present is calcium carbonate; next to this comes calcium sulphate. These two salts are the chief causes of **hardness of water.** For practical purposes, as regards use in domestic matters and in manufactures, the most important classification of waters is into *hard* and *soft.* The degree of hardness varies within wide limits—from rain-water,

which has no hardness at all, to the water from new red sandstone rocks, which sometimes possesses a hardness of 90 degrees; or wells in the gravel, in which it may be as much as 152 degrees.

The following *classification of waters*, according to the degree of hardness, beginning with the least hard and gradually increasing in hardness, is from the sixth report of the Rivers Pollution Commissioners:—1. Rain-water. 2. Upland surface. 3. Surface from cultivated land. 4. River. 5. Spring. 6. Deep-well. 7. Shallow-well water.

Calcium carbonate is the most common cause of hardness, and the hardness produced by it is remediable by boiling or chemical means. Calcium carbonate (chalk) is rendered soluble in water, by the carbonic acid contained in the latter, a double bi-carbonate being thus formed. The air contained in the interstices of the soil through which water passes, often contains 250 times as much carbonic acid as ordinary air. The water, in percolating through the soil, dissolves this carbonic acid, and thus is able to take up considerable amount of chalk.

The amount of hardness in any given water is expressed in degrees, one degree corresponding with a grain of calcium carbonate in a gallon of water. Clarke's soap test is employed to detect the amount of hardness. It consists of a solution of soap of a known strength. Soft water will form a lather at once with this; hard water will only form a lather after all the calcium salt is neutralised. The amount of Clarke's solution required before a lather is produced, will give an estimate of the amount of hardness.

The amount of soap wasted in consequence of the hardness of water is very great. Thus, in the case of water of one degree of hardness, as every gallon contains one grain of chalk, 7,000 gallons would contain 7,000 grains—that is, a pound. But it is found that every degree of hardness—that is, every grain of chalk—wastes 8 or 9 grains of soap; therefore, a pound of chalk,

contained in 7,000 gallons, would waste about 8½ pounds of soap. But nearly all waters are harder than this, and they not uncommonly possess a hardness of 20° or more. If the hardness be 20°, the waste would be 170 pounds of soap. This quantity would be easily used annually in a family of seven or eight persons, if we include the washing of clothes. The amount of money thus wasted can be easily estimated.

The hardness of water is a matter of considerable commercial importance. A chemical commission of the Metropolitan Water Supply, in 1881, estimated that, where soda was not employed, a saving of about a third of the soap used in London for washing linen would be effected, by using soft instead of ordinary London water, and that the saving in labour would be even more considerable. In Glasgow, water possessing 1½° of hardness has been substituted for water of 8° of hardness; and it has been estimated by manufacturers in that town, who use soap in immense quantities, that the consumption of soap has been reduced by one half.

Not only does soft water require less soap, but it is much more suitable for making tea and soup, and for boiling meat and vegetables—both time and fuel being saved. The reason why better tea is made when a little carbonate of soda is added to the water, is that the chalk is by this means precipitated. Five ounces of tea made with soft water, will be as strong as nine ounces made with hard water. It has been stated that nearly one-third of the tea used in London is wasted, owing to the hardness of the water employed in making it.

Carbonate of calcium is precipitated from water by boiling it; carbonic acid being driven off, the neutral salt falls to the bottom of the vessel. This is the origin of the "fur" inside kettles, which lessens their conductivity to heat, and renders necessary a greater consumption of fuel.

The chalk may also be removed by adding to the water, while still in the reservoir, some milk of lime—that is, quicklime made into a milky solution with water. This is done on a large scale at

Caterham, Canterbury, Colne Valley Water-works, etc. The reaction may be expressed thus:—

Calcium bicarbonate + calcium oxide = calcium carbonate + calcium carbonate.

The calcium carbonate, as it is precipitated, carries down with it organic and other matters, thus clearing and purifying the water. The quantity of lime required has been ascertained by Dr. Clarke. He found that by adding one ounce of quicklime to a hundred gallons of water, for every degree of hardness, the water becomes soft and clean in twelve hours.

The hardness due to calcium sulphate is not removable by boiling. It is, therefore, called **permanent hardness**, to distinguish it from the *temporary hardness* of chalk waters, which is removable by boiling. It may, however, be removed by the addition of washing soda to the water, as well as the nitrate and chloride of calcium which are also present; hence the use of washing soda for washing purposes and for boiling vegetables. The magnesium salts are not removable by boiling or soda, contrary to what is usually stated. This is proved by the fact that the "fur" inside kettles does not usually contain magnesium salts.

The amount of hardness varies greatly in different waters. In the deep wells in magnesian limestone, it varies from 14°—57°; in the deep wells from chalk beds, it averages 27°. In the water from Bala Lake, Wales, the temporary hardness is 0°·1, the permanent hardness 0°·3; in the Loch Katrine water there is no temporary hardness, 0°·9 permanent hardness; in the water from the Thames, above Reading, temporary hardness 12°·8, permanent 8°·2, total 21°; from the Thames, above Hampton, temporary hardness 17°·9, permanent 6°·6.

The amount of permanent hardness is always great in water from clays, as the London, Oxford, Kimmeridge, and Lower Lias clays; or in places where there are large deposits of calcium sulphate, as at Montmartre, near Paris (hence the name Plaster of Paris, given to desiccated calcium sulphate). Water from fissures in the clay often contains, also, a large amount of organic matter.

Chlorides are always present in small quantities in water. In the Thames water at Kew, there is ·847 grain per gallon of chlorine, in the New River water 1·1, in Ullswater ·7 grain per gallon. As a rule the presence of 1 grain per gallon indicates contamination with some animal refuse, unless the water is derived from new red sandstone, or brine springs, or from the neighbourhood of the sea. But this is not universally the case, as the Trafalgar square pump-water contains 16½ parts of chlorine in 100,000, and yet is regarded by Frankland as one of the best of waters. We may state the importance of chlorine in water, thus: its absence or the presence of only a minute quantity indicates with a fair degree of certainty the absence of animal contamination, though, on the other hand, in exceptional cases the purest waters may contain more chlorine than the same bulk of sewage.

Nitrates in any water are always suspicious; but their import varies with the circumstances under which they occur. A minute quantity of ammonium nitrate is present in nearly all waters; and the water of deep springs, which is as a rule perfectly free from sewage, may be highly charged with nitrates. Again, if in water containing nitrates, any vegetable growths are present, the nitrates will speedily disappear, having become assimilated by the plants. Nitrates represent a completely oxidised condition of the nitrogenous matter of sewage. Sewage itself generally contains no nitrates. The presence of more than a trace of **phosphates** in a litre of water is a strong indication of contamination with sewage matter.

Lead is an occasional accidental contamination of water. It is usually derived from the action of water on the lead pipes or cistern in which it is contained. The purest and most oxygenated waters act most readily on lead; as also those containing organic matter, nitrates or nitrites. According to some authorities, waters containing chlorides also act on lead, the chloride of lead being sufficiently soluble to produce poisonous symptoms.

Hard waters have the least action on lead; a coating of insoluble

carbonate of lead being formed on the interior of the pipe, which prevents any further action. Thus the use of lead pipes for water containing carbonates or sulphates, or calcium phosphate, is comparatively safe. Hard water containing carbonic acid gas under pressure will dissolve a certain amount of carbonate of lead: this explains cases of lead poisoning from soda water contained in syphon bottles. It acts in the same way as in the case of calcium carbonate, a double carbonate being formed. There is no danger of such a soluble carbonate being formed in the case of ordinary hard water.

Lead is dissolved much more easily by water if other metals are in contact with it, as iron, zinc, or tin, galvanic action being thus set up. Zinc pipes containing some lead are very dangerous, especially with the distilled water used on board ships.

In order to *ascertain the presence of lead in water*, first boil the water down to half its previous bulk in a glass vessel, then add to the suspected water a few drops of hydrochloric (muriatic acid), and pass through the liquid some sulphuretted hydrogen gas (prepared by the action of hydrochloric acid on iron sulphide.) If a brown tint appears after the gas has been passed a short time, lead is probably present, and may be confirmed by other tests.

Traces of Iron are sometimes present in water, giving it an astringent taste. Such water is apt to turn brown; and tea made from it is very dark.

Sulphate of Magnesium (Epsom salts), may be present along with calcium sulphate. If in considerable quantity, it makes the water bitter.

Organic Impurities.—Organic impurities may be either vegetable or animal, the latter being by far the most dangerous. The water from moorlands is often brown, but this is not noxious. Growing plants, again, may be beneficial to water; a certain amount of active oxygen is produced by them, which will oxidise, and so render harmless, any nitrogenous matter present. It must be remembered that water thus oxygenated, easily corrodes lead pipes. Decaying

vegetable matter is objectionable in water, and is apt to set up diarrhœa, and in some marshy districts ague.

The most important organic impurity of water has an animal origin—from sewage; the liquid or solid excreta (*i.e.*, the urine or fœces) from drains or cesspools or the soil gaining accidental access to the water. Besides sewage, the eggs of various intestinal worms are occasionally swallowed with water; and in a few cases, even leeches. Dr. Parks records that in a march of the French soldiers, near Oran, in Algiers, over 400 men were at one time in the hospital, suffering from the effects of swallowing leeches. In some cases, organic matter in water is derived from the putrefying bodies of dead cats, etc. In one case known to the author, the water of a reservoir, in which a drowned man lay for six weeks, was drunk without any apparent bad effects. But whatever the source of the dead organic matter contained in water, it nearly always (1) contains nitrogen as an essential constituent; and (2) tends under the influence of warmth, and therefore especially in summer, to undergo fermentative and putrefactive changes. The putrefaction is produced by minute Bacteria, called "septic organisms;" and in this condition of active putrefaction, water is extremely dangerous. Putrefaction and oxidation are Nature's methods of getting rid of noxious matter, and the ultimate result of these processes is the formation of nitrites and nitrates. These are quite harmless in water, except as an indication that the water has been polluted, and that possibly a certain proportion of the nitrogenous matter may still remain unoxidised, and powerful for evil. A preliminary stage to the formation of nitrates in impure water, is the formation of ammonia from the same organic contamination; so that one may meet with a water which contains (1) *nitrates* and *nitrites*, representing completely oxidised and harmless contaminations; (2) *ammonia* and the salts of ammonia representing an intermediate stage of organic matter, and still dangerous; and (3) *unchanged organic matter*. (4) *Free nitrogen* may be dissolved from the air, but is quite harmless.

The amount of nitrogen present in the first three of these forms is taken as an estimate of the amount of organic pollution.

The **Presence of Nitrates or Nitrites** is not in itself dangerous, but important as indicating a former contamination. As already stated, their absence is not a certain proof of the absence of sewage contamination, nor can their presence be taken as a proof to the contrary, unless the *source* of the water is taken into account. They give a peculiar freshness to water, and, along with carbonic acid gas, make churchyard and similar waters pleasant to the eye and agreeable to the palate, although extremely dangerous.

The **Presence of Ammonia** or its salts, commonly indicates putrefied but unoxidised organic matter. In minute quantities, it may occur, unaccompanied by the organic matter which is calculated as albuminoid ammonia or by excess of chlorides, in soft water and probably even in rain water. As a rule, a potable water should contain very little of it. It can be separated from the water by distillation, and its presence determined by Nessler's test. This consists in adding a liquid obtained by dissolving iodide of potassium in a solution of corrosive sublimate (Nessler's solution) to the suspected water. If free ammonia is present, a yellow or brown coloration is produced.

When a considerable amount of free ammonia is present in water, urinary contamination has probably occurred. Urine contains urea (N_2H_4CO), which when putrefied becomes carbonate of ammonia. It also contains a considerable amount of chlorides; the presence of the latter would therefore usually support the conclusion deduced from the presence of much ammonia.

The **Presence of Unchanged Organic Matter** is especially dangerous. It may still persist even after all the ammonia present has become oxidised into nitrates. It is this persistent organic matter which is to be dreaded in drinking water. Its amount can be estimated (after having first calculated the amount of urea and ammonia by adding carbonate of soda and distilling, over a portion of the water), by subsequently adding to the water a solution of potassium permanganate (Condy's fluid) and caustic potash and distilling a

second time. By this means the nitrogen of the organic matter is separated as ammonia, and its amount can be estimated by Nessler's solution. Owing to its being derived from nitrogenous matter, this ammonia is called **Albuminoid Ammonia**, to distinguish it from the free ammonia separated by carbonate of soda. According to Wanklyn, ·06 to ·08 milligram of albuminoid ammonia per litre (*i.e.*, ·06 to ·08 parts in one million parts of the water) is the limit distinguishing clean from unclean water. The same authority states thas the Southwark and Vauxhall and the Lambeth Companies supply water yielding an average of ·14 milligram of albuminoid ammonia per litre.

The following analysis, from "Water, Air, and Disinfectants," by W. N. Hartley, give examples of good and bad waters :—

IN 100 MILLION PARTS OF WATER.		
LONDON WATER SUPPLY. 1872.	FREE AMMONIA.	AMMONIA FROM ORGANIC MATTER.
New River Company, Oct. 2 ..	2	8
" " *Nov. 21* ..	1	6
East London Company, Oct. 10 ..	1	4
" " *Dec. 4* ..	1	18
Kent Company, Feb. 7	1	2
" " *Nov. 20*	1	2
Manchester Town Water	1	6
" "	1	7
Edinburgh	0	7
Glasgow	0	8
Chester	0	7
Scarborough	1	6
Birkenhead	0	2
Chelmsford	8	2
Leek	0	2
Lytham	0	1
Guildford New Supply	0	1

It is evident from these analyses that, even in the most impure waters, the amount of impurity is very small, so that a very delicate and exact analysis is required.

The following **qualitative test** is of considerable value, as indicating the presence of organic matter, though not estimating its amount:—Fill a tall colourless glass vessel nearly full with the water to be examined, and add as much solution of potassic permanganate (one grain to two ounces of distilled water) as will give a distinct pink tinge to the water. Then fill another vessel of equal size, with distilled water, and add the same amount of the permanganate solution. Watch the two liquids for a time, noticing any difference between the tints that may appear. If no browning and decolouration of the first specimen occurs, as compared with the second, it proves the purity of the water; if a slow decolouration occurs, it shows the presence of vegetable matter; if a rapid discolouration, it proves the presence of organic matter having an animal origin, or of sulphuretted hydrogen, iron, or nitrites. Sulphuretted hydrogen is rarely present, and can be easily recognised by its smell; iron or nitrites are readily distinguished by their appropriate tests. In the absence of these, the rapid decolouration is a certain indication of animal contamination.

To obtain a complete **quantitative analysis** of water, at least two gallons are required. According to Dr. Parkes, in wholesome waters the total solids should not exceed eight grains per gallon, except in the case of chalk waters, and then should not go beyond fourteen grains per gallon. In "usable" water, the total solids should not be over thirty grains, unless they are chiefly a mixture of sodium chloride and calcium carbonate, when they may run up to fifty grains per gallon without any apparent bad effects.

With regard to the organic matter present in water, chemical analysis alone cannot ascertain the safety or danger of drinking any given specimen. The amount of organic impurity present in water, which is competent to produce disease, may be extremely small, while it may be considerable in another water, which can be

drunk with impunity. All that chemical analysis can tell us is, that so much nitrogen is present; but whether it is derived from the excreta of healthy persons, or represents the nitrogenous matter of the germs of cholera or some other disease, we cannot ascertain by chemical analysis. According to Dr. Frankland, "water mixed with healthy sewage is quite wholesome to drink, and probably half the population are drinking such water."* It is when the sewage is undergoing active putrefactive changes, and still more when it contains the living germs of disease, that it is dangerous.

Dr. Cory has made experiments with different waters, tending to prove that the stools of healthy individuals or of typhoid fever patients can be added to water, without their exact character being capable of determination by chemical analysis, and that an amount of organic matter capable of producing specific disease was undetected by the same process.

The infective diseases propagated by water are due to microscopic bacteria, the presence of which would have a scarcely appreciable effect on the composition of water as determined by chemical analysis. Professor Huxley put the matter extremely well in a discussion on river-waters at the Chemical Society. He asked the president if there was any known method by which, if a drop of Pasteur's solution were placed in a gallon of water, its constituents could be estimated. The answer was that "it was doubtful;" when Professor Huxley proceeded to shew that every cubic inch of that gallon of water would contain from 50,000 to 100,000 bacteria, and *one drop* of it would be competent to excite putrefaction in any substance capable of undergoing it. These results have been called in question, and it has been urged that although the original Bactina in a dangerous specimen of water may not be detectable, they multiply so rapidly, that in a day or two, chemical analysis would discover them by their products.

The case with regard to the value of chemical analysis for estimating organic matter in water may be stated thus: the

absence of organic matter in any larger proportion, than nearly always occurs in pure water, does not absolutely prove that a given water is safe; nor does the presence of organic matter in larger proportions prove that the water is necessarily dangerous. One is helped in many cases by a knowledge of the *source* of the water; and it is possible that *microscopic examination* may in the future give more reliable results than chemical analysis. Koch's gelatine process, by means of which the organisms of water are collected and examined, is especially full of promise.

Figure 3 shows a number of organic impurities in water derived from the Thames at Richmond and from an impure cistern, including both animal and vegetable organisms.

FIG. 3.
Organic Impurities found in Water, magnified 220 diameters.

CHAPTER XII.

ORIGIN AND EFFECTS OF THE IMPURITIES OF WATER.

Origin of the Impurities of Water.—Effects of Mineral Impurities.—Effects of Organic Impurities.—Typhoid Fever and Cholera in relation to Water.—Effects of an Insufficient Supply of Water.

Origin of Impurities of Water.—The classification proposed by Dr. Parkes will be followed. He divides the impurities into—

1. **Those Received at the Source.**—The character of water varies with the geological structures through which it has passed; with its origin from the subsoil or cultivated land, or deep wells, or graveyards, or near the sea, etc. It cannot be too distinctly urged that it is a mistaken policy to commence with an impure water and proceed to purify it. Inorganic impurities are of much smaller consequence as regards health than organic; hence the great advantage of deep well water over river water.

2. **Impurities of Transit from Source to Reservoir**, acquired during the flow in rivers, canals, or other conduits. These impurities have been broadly divided by the Rivers Pollution Commissioners into "**sewage**" and "**manufacturing**;" the former including the solid and liquid excreta, the house and waste water, etc.; the latter including the refuse from manufacturing processes, as from dye and bleaching works, tanneries, etc.

3. **Impurities of Storage**, whether in wells, reservoirs, or cisterns. Organic impurities are commonly received at this stage. A well, for instance, drains the soil around it in the shape of an inverted cone, with a very broad base.

4. **Impurities of Distribution.** Lead, and occasionally other metals, are dissolved by certain waters. If the pipes are left empty, as with an intermittent supply, sewage may be drawn into them, and sewer gas may penetrate into their interior; in a few cases coal-gas has similarly found its way into the water pipes.

Effects of Impure Water.—1. **Effects of Mineral Impurities.**

Suspended mineral matters in unfiltered water occasionally produce diarrhœa. The hill diarrhœa of some parts of India has been traced to water containing fine mica particles in suspension.

Hard water is said by some to be hurtful, though the general impression is that the salts causing hardness are innocuous when not amounting to more than 12 or 16 grains per gallon. Persons in the habit of drinking hard water find soft water unpalatable. Hard water is commonly thought to produce calculus. In Norwich and Norfolk the water is hard, and there is an excess of calculous disease in these districts, but according to Dr. Richardson, it is not attributable to the water. Professor Gamgee says that sheep are particularly affected by calculus in limestone districts. Calculus is common at Canton among the Chinese, but they always boil their water. The salts producing permanent hardness are much more injurious than calcium carbonate, dyspeptic symptoms having arisen when there were only 8 grains per gallon of calcium sulphate and chloride, and magnesium salts. A bitter taste in water indicates the probable presence of excess of magnesium sulphate, and this may cause griping pains in the abdomen.

Goitre, a swelling of the thyroid gland in the neck, is often associated with the use of drinking water from magnesian limestone formations. In some parts of Yorkshire, Derbyshire (hence the name "Derbyshire neck"), Hampshire, and Sussex, it still prevails, though much less commonly than formerly. In Switzerland, cretinism, a congenital form of idiocy, frequently occurs in the same districts as goitre, and is apparently due to similar conditions. The exact origin of goitre is yet uncertain. In many magnesian limestone districts it is unknown, while in some districts where this formation is absent, cases of goitre have occasionally occurred. The latest view is that sulphide of iron is the cause of goitre, and it is said that this is always present in magnesian limestone districts. Others hold that a miasmatic poison in the water is necessary for the causation of goitre, in addition to the metallic salts.

Lead dissolved in water may produce serious and lasting ailments, and they are often present for a long time before their cause is detected. The amount of lead capable of producing poisonous symptoms has been as little as $\frac{1}{100}$ grain per gallon of water (Dr. Angus Smith). According to Dr. de Chaumont, $\frac{1}{10}$ grain per gallon, that is 1 part in 700,000 is usually required to produce such symptoms. In the well-known case of the poisoning of Louis Phillippe's family, at Claremount, there was $\frac{7}{10}$ grain of lead in a gallon of water; and this affected 34 per cent. of those who drank it. The symptoms produced by lead poisoning are those of indigestion, accompanied by colic; a blue line at the junction of the gums with the teeth; "wrist drop,"—a paralysis of the muscles of the forearm, or some other paralysis; and if the poisoning is continued, attacks of gout, followed by its usual consequence, chronic kidney disease. The latter affections only occur when the poisoning is continued for a long time, as in the case of painters or type-setters: poisoning from water is generally discovered before any other than dyspeptic symptoms are produced.

The presence of traces of iron in water may give it a slightly astringent taste: and such water is liable to cause headache and constipation.

2. **Effects of Vegetable Impurities.**—Living plants are unobjectionable, but decomposing vegetable matter is apt to produce diarrhœa and other severe symptoms. Assuming that the specific fevers are due to the development in the organism of minute bacilli, we ought to consider these under the present heading; but inasmuch as they always accompany animal matter, in sewage, etc., they will be more conveniently studied in the next section.

3. **Effects of Animal Impurities.**—Animal impurities of water are by far the most important from a sanitary point of view. Their most common source is from cesspool and sewer contamination; but they may arise from other accidental causes. The quality of the contamination is more important than its quantity; and this will explain why water containing a large amount of sewage may

be drunk for a prolonged period with impunity, while at another time the least trace, if it contain the active germs of disease, will lead to serious mischief.

Suspended animal impurities are apparently much more dangerous than those completely dissolved. Hence the examination of the colour and turbidity of drinking water is very important. Fœcal contamination is by far the most dangerous of all, and chiefly so when it is derived from a patient suffering from some communicable disease, belonging to the same class as typhoid fever.

Certain Parasites occasionally are swallowed with water in the form of embryo or egg. The liver fluke, round worm, and less frequently other kinds of entozoa have been introduced in this way. The occasional swallowing of small leeches has been already noticed, giving rise to hœmorrhage.

Diarrhœa is often due to animal contamination of water. It most commonly occurs in summer, when all the circumstances are favourable to active fermentative changes, and proves very fatal to young children. There is some reason for believing that the summer diarrhœa of children has a specific bacterial origin. The presence of fœtid gases in water may lead to diarrhœa, as when the absorption of sewer gas is allowed by the overflow pipe of a cistern opening into the soil pipe.

Dysentery, like cholera and typhoid fever, may be propagated by water contaminated with the stools of a patient suffering from the same disease. In some cases it seems to have arisen where the water contained organic filth of a non-specific origin.

Ague is usually propagated by the air of malarious districts, but occasionally the water of marshes has produced it. In such cases the attack has developed rapidly, and been very severe.

Typhoid fever may originate in the inhalation of the sewer-gas from a drain, or the drinking of water contaminated with sewage. Probably infection is much more certain in the latter case than in the former, as well as much more frequent. In a report of the

Local Government board it is stated that of 142 epidemics of typhoid fever observed in various localities, in 125 the epidemic had no other determining cause than the use of water containing organic impurities.

There is a difference of opinion as to whether ordinary decomposing sewage will produce typhoid fever, or whether it must contain the stools of a typhoid patient. There can be no doubt that contaminated water may be drunk for a long time without producing typhoid fever. A report given by Dr. Ballard to the Local Government Board (1872) strongly supports this view. Water containing a large amount of animal pollution had been drunk by the inhabitants of the village of Nunney for years without causing fever; but a person suffering from typhoid fever came in May, 1872, to the village from a distance, and his excreta were washed into the stream supplying the village with drinking water. Between June and October 1872, 76 cases of typhoid occurred out of a population of 832 persons. All those attacked were in the habit of drinking the stream water. All who used filtered rain or well water escaped, except one family who drank the water of a well only 4 or 5 yards from the brook. Dr. Parkes concludes from this case, that "common fœcal matter may produce diarrhœa, which may perhaps be accompanied with fever, but for the production of enteric or typhoid fever the specific agent must be present." In some cases, however, it is impossible to trace a previous case of typhoid, as where the disease has originated under insanitary conditions in isolated farm-houses. It must, therefore, be acknowledged that exceptionally filth contaminations of drinking water are competent alone to produce symptoms indistinguishable from those of typhoid fever. We may explain this by assuming that Bacteria are constantly present in the atmosphere or soil, capable of assuming a violent and infective character, under certain exceptional conditions of putrefaction of sewage matters.

The contamination of water with sewage products may occur in

various ways. In country places surface wells and small streams commonly supply the drinking water, and these are frequently contaminated by putrefied sewage, if not by actual typhoid stools. The accompanying illustration shews the percolation of liquid excretory matters from an out-door closet through the porous gravel,

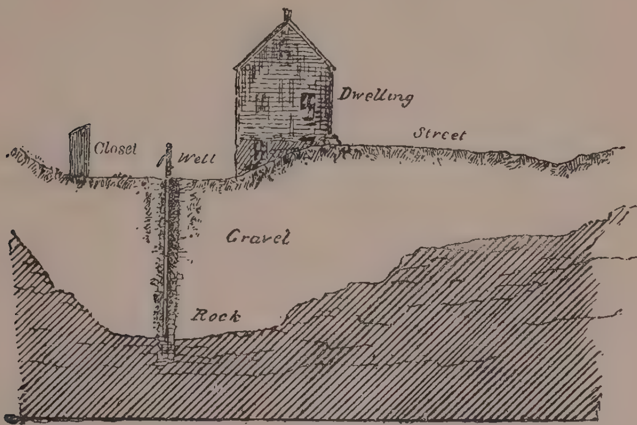


FIG. 4.

into a neighbouring well; the result being an epidemic of typhoid fever among those who drank the water of the well. Alterations in the level of the subsoil water are sometimes followed by an outbreak of typhoid; this is also true of scarlet fever, according to Baldwin Latham. A sudden fall of rain occurs, and the excess of water in the soil absorbs the soakings from country privies or cesspools, and carries them into the nearest well. Several severe epidemics have been traced to this source. The percolation and filtration of tainted water through a considerable tract of porous land is in many cases insufficient to purify it, as proved by a remarkable epidemic in the small village of Lausen, in Switzerland.

In other cases sewage matter gains access into leaky water-pipes, or from the drains into the cistern by means of the overflow pipe

of the latter, or from the water-closet when a separate cistern is not provided for it.

Milk may, by the admixture of water, become contaminated with typhoid matter. Such milk has occasionally produced epidemics. Where the water is very impure, even the small amount used in washing cans may suffice to produce poisoning. In an epidemic investigated by the author, the outbreak was strictly limited to families supplied with milk from a particular dairy, members of nineteen families being attacked within short intervals of each other. In one family the influence of the milk was very curiously proved. There were eight children, of whom the three youngest drank cold milk every day while the five older children only had milk with their coffee, and that boiled. The three youngest children were all attacked at the same time, while the rest of the family escaped.

The importance of preventive measures for typhoid fever is evident when it is stated that about 5,000 persons die annually in England and Wales from this disease alone.

Cholera was first proved by Dr. Snow, in 1849, to be due to the specific poison of cholera gaining an entrance into drinking water. Whether it can be produced by animal matter, not of a specific character, is still an open question; but if this ever occurs, it must be exceptional.

The vomit and intestinal evacuations of cholera patients are practically the sole means of infection; and these are not dangerous in the fresh condition, but only after three or four days, when fermentative changes have been set up.

The close connection of the spread of cholera with an impure water supply has been repeatedly shown in this country. The cholera epidemic of 1854 was very severe in the southern districts of London. At that period these districts were supplied with water by the Southwark and Vauxhall Company, deriving its water from the Thames at Battersea; and by the Lambeth Company, having its intake at Thames Ditton, where the water was infinitely

purer. The two companies were acting in rivalry, so that in many streets their mains ran side by side, and houses in the same street, similar in all other respects, received a different water supply. An investigation of the distribution of cholera in these districts gave the following results :—

	Population in 1851.	Cholera deaths in 14 weeks.	Cholera deaths per 10,000
Houses supplied by Southwark Co....	266,516	4,093	153
„ „ „ Lambeth Co. ...	173,748	461	26

The facts, when examined in detail, brought out still more strikingly the exemption of the houses supplied by the Lambeth Company; next-door neighbours being attacked, when their supply of water was from the Southwark Company.

A low temperature of the air prevents the development of the cholera germs. The prevalence of cholera in Russia is quoted as proving the contrary; but in that country the indoor temperature is commonly maintained at a high point; ejecta are often cast out round the dwelling-houses; and in cold weather, snow derived from the same vicinity is melted and drunk, thus providing a ready entry into the system for cholera or any other germs which may be present.

Diphtheria has been attributed in some cases to polluted water. In many outbreaks of diphtheria, impure water has been found along with other insanitary conditions, but diphtheria has never been proved to be due to impure water. It is commonly due to direct infection from patient to patient, but may be caused by infection from lower animals, or by the effluvia from defective drains, foul ashpits, etc.

Scarlet Fever might possibly be conveyed by contaminated water, and is often carried by infected milk; but it is usually carried from person to person. According to one good authority, epidemics of scarlet fever are occasionally due to a sudden alteration in the level of the subsoil water (Baldwin Latham).

Sore Throat not uncommonly is caused by bad drains, whether the poison from these is inhaled or drunk in the water.

Erysipelas has occasionally a similar origin.

A curiously localised epidemic of boils occurred near Frankfort, in 1848, and was traced to the drinking of water containing sulphuretted hydrogen.

Effects of an Insufficient Supply of Water.—The influence on personal health is most baneful. Water is used sparingly for purposes of cleanliness, with the necessary results that cutaneous diseases become more common, and the whole body suffers; the linen is imperfectly and infrequently washed; the house becomes dirty; drains are imperfectly flushed; the streets are not cleaned; and the whole atmosphere becomes loaded with impurities. According to Dr. Parkes, it is probable that the remarkable cessation of spotted typhus among civilized and cleanly nations, is not merely owing to better ventilation, but also to more frequent and thorough washing of clothes.

Insufficient cleansing of sewers, owing to a deficient supply of water, has a very important influence on the spread of typhoid fever and epidemic diarrhœa. A heavy fall of rain often causes a rapid diminution in their prevalence.

CHAPTER XIII.

THE PURIFICATION OF WATER.

Distillation.—Boiling.—Chemical Measures.—Filtration on a Large Scale.—Domestic Filtration.—The Varieties of Filters.

When a public water-supply is provided, it is natural to suppose that the water is furnished pure and fit for use; but this, unfortunately, is often not the case. The reports, for instance, of the condition of the London Water Supply, not infrequently shew that it is turbid and impure; and this is especially the case

when, during heavy rain-falls, mud and refuse are washed into the streams or reservoirs. Rain-water and well-water nearly always require to be purified before use.

METHODS OF PURIFICATION.—The only absolutely certain way of obtaining pure water is by **Distillation**; but this plan is quite inapplicable to water on a large scale, and distilled water is not so palatable as ordinary water. The distillation of water is more especially required on board ship, during long voyages, and should be followed by the use of some measure to secure efficient aëration.

2. **Boiling the water** serves to get rid of the temporary hardness, and the chalk carries down with it a considerable amount of any organic matter that may be present. Boiling deprives the water of its dissolved gases, and renders it flat; it is desirable, therefore, to filter it after boiling. These two measures form a great protection against infectious diseases; and if the water is at all suspicious, it ought, in all cases, to be boiled and filtered. It is very improbable that the germs of disease would resist the temperature of boiling water. According to Prof. Sanderson, the common Septic Bacteria die at the temperature of 110° Cent., or 230° Fahr. It is possible, however, that the spores of these organisms may resist a higher temperature than the adult forms. Rev. W. H. Dallinger, F.R.S., found that although a temperature of 150° Fahr. killed all the adult monads, young monads continued to appear and develop in an infusion which had been raised to 260° Fahr. Practically, however, it is found that thorough boiling of water (as also of milk), is an effectual preventive against the conveyance of infection by its means.

3. **The Exposure of Water in Divided Currents to the Air.**—The water is passed through a fine sieve, so as to cause a minute division of it. It is said that organic matter is oxidised by this process, and certainly sulphuretted hydrogen and offensive organic vapours are removed by it.

4. **The Immersion of Charcoal or Iron Wire** in the water decomposes organic matter. Charring the interior of casks in which

water is kept is a very effective process, but the charring requires to be repeated.

5. **The Influence of Plants and Fishes.**—In reservoirs the presence of a moderate quantity of living plants is beneficial, by aiding oxidation of any organic matter present. The destruction of fish has led to a rapid increase in the number of small crustaceans on which the fish had lived, rendering the water impure and nauseous (Rankine.) The remedy is to re-stock the reservoir with fishes.

6. **The Addition of Chemical Substances.**—(1) *Clarke's process* consists in adding milk of lime to the water in the reservoir on a large scale. By this means calcium carbonate is precipitated, but no effect is produced on calcium and magnesium sulphates and chlorides. The calcium carbonate carries down with it suspended and possibly dissolved organic matter; consequently this process is valuable sanitarily as well as commercially.

(2) *Carbonate of Soda* added to boiling water throws down calcium carbonate, and possibly lead if present. Much less is required when added to boiling than to cold water.

(3) *Aluminous salts* are very effectual in removing suspended organic matter, if the water contains calcium carbonate. On the addition of alum, calcium sulphate and aluminium hydrate are formed, both of which fall to the bottom, carrying with them other impurities. The amount of alum required is about 6 grains per gallon of water. It is doubtful however whether dissolved organic matter is precipitated. If the water is not hard, a little calcium chloride and carbonate of soda should be put in before the alum is added, in order that a precipitable substance may be formed.

(4) *Potassium permanganate* readily removes the offensive smell of stagnant water, but as it commonly gives a yellow tint to the water, its use is objected to. The addition of a little alum will sometimes carry down the decomposed permanganate. According to experiments of Dr. Parkes, it is doubtful if all organic matters are oxidised by the permanganate; some organic substances, and

especially those in solution, appearing to be untouched by it. We may regard the addition of Condy's fluid as a valuable preliminary to the alum process. It is also very serviceable in cleansing filters.

(5) *Perchloride of Iron*, in the proportion of $2\frac{1}{2}$ grains to a gallon of water, has been found to completely purify water from finely suspended organic matters and clay.

7. Filtration. Where filtration is required, it should be done on a large scale, by the company supplying the water. If the water supply is pure, as in Liverpool, Glasgow, and Manchester, domestic filtration is not only useless, but likely to do more harm than good.

Filtration **on a large scale** is generally carried on as follows:—A preliminary step consists in collecting the water into settling reservoirs, wherein the more bulky substances subside. The water is then filtered through beds of gravel and sand, containing perforated tubular drains below, into which the filtered water flows. The drains are covered by a bed of gravel about 3 feet deep, over which is spread a layer of sand about $1\frac{1}{2}$ to 2 feet deep. Sharp angular particles of sand are the best; and the gravel should gradually increase in coarseness as it descends. The depth of the water should never be above 2 feet; about 70 to 75 gallons is the usual quantity passing through each square foot of the filtering bed in 24 hours. It is essential that the filtration should be downward and intermittent; and that, in the intervals of filtration, the filtering bed should be freely exposed to the atmosphere, and occasionally changed.

The effect of this filtration is chiefly *mechanical;* it separates any coarse suspended matter, whether organic or inorganic. Whether it is competent to stop the minute organisms to which in all probability specific diseases are due, is very doubtful.

Some *chemical* action may also occur during filtration. It is possible that the air contained in the interstices of the sand may act on the organic matter contained in the finely divided current of water, and oxidise a certain amount of it. But such

oxidation is incomplete, and does not suffice to render the germs of disease inert.

Other materials have been used in filtration in addition to sand. *Sponge* has considerable power in arresting suspended particles, but its use is not to be recommended. *Animal charcoal* (deprived, by means of hydrochloric acid, of the salts it originally contains) is one of the best filtering materials; and its use, on a large scale, is advised by Dr. Frankland, spite of its expense, and the fact that it requires renewing at intervals. A weak solution of Condy's fluid is decolorised by passing through animal charcoal; and there is a general concensus of opinion, that both suspended and dissolved inorganic and organic matters are, to a large extent, removed by charcoal. According to Mr. Byrne, the purifying action of animal charcoal on water containing organic matter, ceases after a time, though it can be restored by passing a little Condy's fluid through the filter. This is confirmed by Mr. Chapman, who obtained from a charcoal filter as much organic matter as the water passing through the filter had previously contained. On the other hand, Dr. Letheby obtained some charcoal which had been used for filtration two years, and found that it was still capable of depriving water of colour and organic matter, and that the organic matter had not accumulated. One is compelled, therefore, to infer that it had been oxidised; and this agrees with the well-known power of charcoal to condense gases in its interior, and oxidise noxious vapours. The conclusion seems to be that when the amount of organic matter in water is small, the purifying action of animal charcoal is almost permanent. Dr. Frankland has suggested that there are two kinds of organic matter, one of which is not acted on by charcoal. The condition of the organic matter is important; it has been shewn that fresh albumin passes through unchanged, while about 95 per cent. of decomposing albumin is arrested.

In addition, the constancy with which a filter is used has great influence; if long unused, the charcoal is liable to get dirty; and

if always wet, the oxygen held in its substance—which enables it to oxidise organic matter—becomes exhausted.

Vegetable charcoal is decidedly inferior to animal in purifying water. A mixture of *animal charcoal* and *spongy iron* forms a very good purifier of water.

Domestic Filters are in common use in households, and if regularly superintended, are of considerable value. Where an ordinary filter is too expensive, an efficient one may be made as follows at a very trifling expense:—Take an ordinary earthenware garden flower-

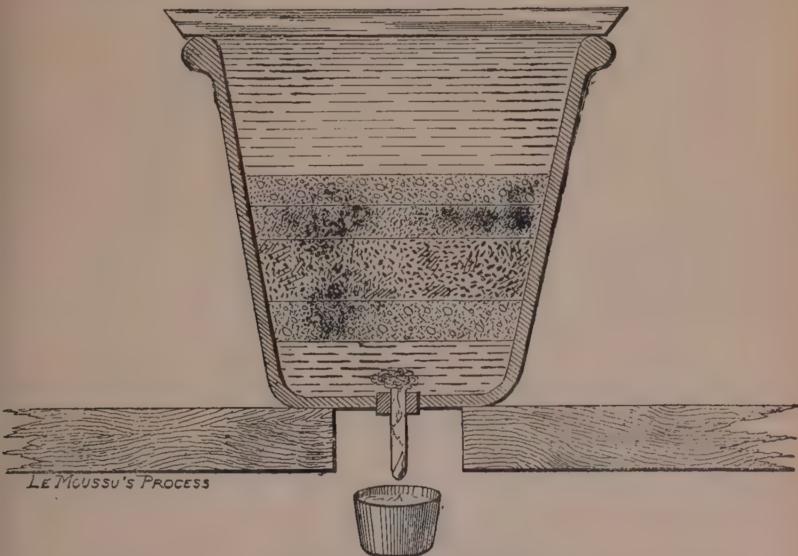


FIG. 5.—A HOME-MADE FILTER.

pot; cover the hole with zinc gauze, or fit it with a piece of glass tube and a sponge, as in *Fig. 5;* then get some rather small gravel, wash it thoroughly, and put it in the pot to the height of about three inches; next buy two pounds of animal charcoal, and after well washing it by pouring boiling water on it several times, and allowing it to settle, put it on the gravel, and press it well down,

making about four inches deep of charcoal; next take some white sand, and after washing it well, put it on the charcoal; and finally, some more gravel may be placed on this. The filter is now ready for use.

All filters tend to become clogged by the deposit of suspended organic matter and calcium salts. Animal charcoal ought to be renewed or cleaned every three or four months; spongy iron remains good a year at least. To purify a charcoal filter, brush its surface, if the charcoal is in the block form. Then pour into the filter four or six ounces of a mixture of equal parts of Condy's fluid and water, to which ten drops of strong sulphuric acid have been added; and after it has drained through, pour in a solution of a tablespoonful of pure hydrochloric acid in two or three gallons of water. Subsequently pour through the filter two or three gallons of distilled or good rain water, and then the filter is ready for use again.

When the charcoal or other filtering material can be taken out, it ought to be washed, then boiled with a little Condy's fluid, and subsequently dried in an oven.

Animal charcoal is the chief material used for household filters, and when well prepared, forms a good filtering material; but, if inferior in quality, and especially if not periodically cleaned, it may form a breeding place for thousands of minute worms. The sixth report of the Rivers Pollution Commissioners states: "The property which animal charcoal possesses in a high degree of favouring the growth of the low forms of organised life, is a serious drawback to its use as a filtering medium for potable waters." If completely free from phosphates, it is probably to a large extent, if not entirely, deprived of this drawback. At the same time, they state that "*fresh* animal charcoal removes not only a large proportion of the organic matter present in water, but also a not inconsiderable amount of mineral saline matters." According to Dr. Parkes, "on an average there is no charcoal or magnetic carbide filter now in the English market which cannot be relied upon to remove 40 per cent. of dissolved organic matter, and in some cases more;" while

the amount of hardness (especially that due to calcium carbonate), and of nitrites and ammonia is also lessened, and common salt is arrested by some filters to a slight extent.

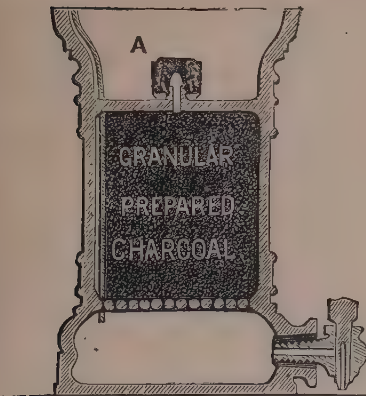


FIG. 6.
GRANULAR CHARCOAL FILTER.

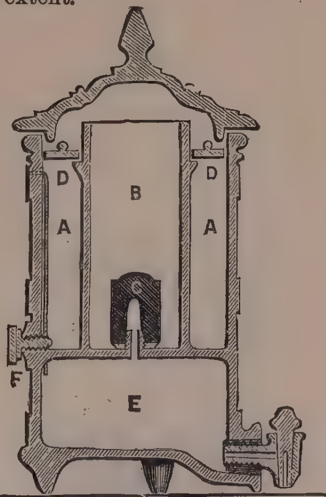


FIG. 7.
MANGANOUS CARBON REFRIGERATOR FILTER.

The Patent Granular Carbon Filter, manufactured by Messrs. Doulton & Co., contains a block of manganous carbon (A *Fig. 6*), which is screwed on to the plate covering the block of granular carbon and thus ensures a double filtration of the water.

The Manganous Carbon Refrigerator Filter, of the same firm, is similar to the last in principle, but contains a compartment in which ice or a freezing mixture can be placed to keep the water cool in hot weather.

In *Fig. 7*, A A is the ice-compartment. B is the space for unfiltered water. C the filtering block of patent manganous carbon. D D the cover to the ice-compartment. E the space for filtered water. F the outlet for freezing mixture.

In both these filters, manganous carbon is used. This is

prepared by mixing granular animal charcoal with oil and black oxide of manganese, and then heating strongly out of contact with the air. In this way, according to Dr. Bernays, the oxidising power of charcoal for organic impurities is greatly increased.

The Patent "Filtre Rapide," of M. Maignen, differs from any other known to be in the market, in two important respects. The charcoal is not in block form, but as a granular powder, which can be easily removed and its place taken by a new supply. And,

FIG. 8.—MAIGNEN'S PATENT FILTER.

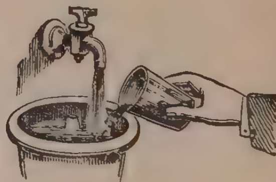


FIG. 9.—SETTING

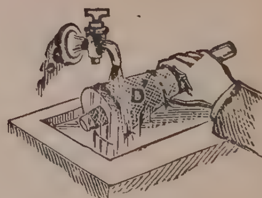


FIG 10.—CLEANSING.

in the next place, the charcoal is mixed with lime ("carbo-calcis"), and in this way serves actually to soften the water which is passed through it, for a time at least. In *Fig. 8* is shewn a vertical section of this filter. R is the reservoir containing the filtered water. As the filtering apparatus simply rests loosely in the filter

case, R is easily accessible for cleansing. M, the filtering frame, is covered with asbestos cloth, E, which is tied with cords of asbestos. D is a layer of powdered "carbo-calcis," which has been deposited on the asbestos by mixing the carbo-calcis in a tumbler with water, and then pouring it into the filter, as shewn in *Fig. 9.* C is granular carbo-calcis put in loosely, to fill up the space between D and the screen B. Water put into the upper part of the filter, goes first through the granular carbo-calcis, then through the layer of powdered carbo-calcis and the asbestos cloth. It becomes partially oxygenated by the air contained in the funnel-shaped part of the apparatus (as shewn by the single arrow). The great advantage possessed by this filter, is the fact that it can be easily cleansed and new filtering material inserted.

Besides animal charcoal, the chief filtering materials are spongy iron, the magnetic carbide of iron, and silicated carbon.

Spongy iron is prepared by the reduction of hæmatite ore with fusion, so that the iron is obtained in a porous and finely-divided condition The Rivers Pollution Commissioners found spongy iron to be "a very active agent, not only in removing organic matter from water, but also in materially reducing its hardness, and otherwise altering its character."

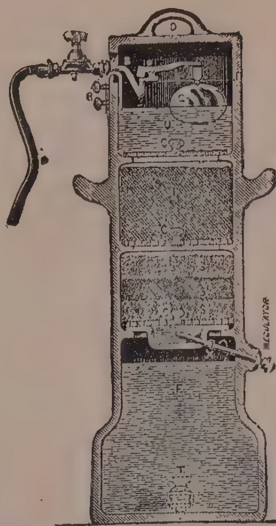


FIG. II.—SECTION OF SPONGY IRON FILTER.

The free ammonia in a water is sometimes increased after filtration through spongy iron, owing to reduction of nitrates.

Fig. 11 represents a vertical section of one of the more complex spongy iron filters, in which U is the unfiltered water, B the ball-cock, V a screw-valve, I spongy iron, S S′ S″ prepared sand, F filtered water, T stop-cock, A regulator.

The so-called *magnetic carbide of*

iron is obtained by heating hæmatite ore with sawdust, and forms an admirable purifier of water.

Silicated carbon consists of 75 per cent. of charcoal and 22 per cent. of silica with a little oxide of iron and alumina. Mr. Wanklyn has shown that repeated filtration of river water by this material makes it as free from organic matter as deep spring water.

The *Pasteur-Chamberland* filter is composed of 5 or 6 porous earthenware cylinders. It is fixed on to the tap; the water is forced under pressure through these and the passage of micro-organisms is entirely prevented.

All filters require cleansing and renewing at intervals. They should be allowed to run dry occasionally, in order that the filtering material may become aërated. It is not advisable to allow water to remain stagnant in a filter.

The use of sponges in domestic filters is pernicious. They soon become dirty, and are apt to be infested with microscopic growths.

CHAPTER XIV.

COMPOSITION AND PROPERTIES OF AIR.

The Constituents af Air.—Nitrogen, Oxygen, Ozone, Ammonia, Carbonic Acid.—The Changes in the Air produced by Respiration.

An abundant supply of fresh air is necessary at all times. And yet its importance is being constantly ignored in practical life. Strenuous efforts are made to ensure a supply of food, and water is commonly filtered or otherwise purified before drinking; but we are content to live in an impure atmosphere, which hardly suffices for the preservation of life, and certainly not of health. Deprivation of food, or even of water, only kills after several days or weeks; deprivation of air kills in a few minutes. Only about three pints of water are required daily, while at least 1,500 gallons of air are necessary for carrying on the vital

functions; and yet, through ignorance or carelessness, the provision of pure air is almost universally neglected.

Composition of Air.—The air is a material substance; it constitutes a gaseous ocean in which we live, as fishes live in water. In virtue of its weight, it exerts a pressure of about 15 lbs. on every square inch. This pressure is usually measured by the *barometer*, and is equivalent on an average to that of a column of 30 inches of quicksilver. Being possessed of weight, the density of air varies with its height, diminishing as the height above the sea-level is increased. If the air were of the same density throughout, its limit would be reached at a height of about five miles.

Chemically, air consists of a mixture of various gases and vapours. These are chiefly **Oxygen** and **Nitrogen**; but in addition, there are minute quantities of carbonic acid, water vapour, ammonia, ozone, and suspended matters.

The oxygen and nitrogen exist in the proportion by volume of 20·9 of oxygen to 79·1 of nitrogen, or of 23·16 grains of oxygen to 76·84 of nitrogen, by weight.

These two gases do not exist in chemical combination, but mechanically mixed. This is proved by the fact, that they do not exist in air in the proportion of their combining weights, or any multiple of these; that the proportion varies slightly at different parts; and that the air which is dissolved in water does not contain the nitrogen and oxygen in the proportion 4 to 1 (as in the atmosphere), but in the proportion 1·87 to 1. This means that oxygen, being more soluble in water than nitrogen, has dissolved in a larger proportion; as it certainly would not have done, had the oxygen and nitrogen been chemically combined. The oxygen dissolved in water supplies fishes with the necessary oxygen for their respiratory processes. Similarly the oxygen in the atmosphere is its most essential constituent, being required in all processes of oxidation (*i.e.*, combustion), whether in living organisms or in the inanimate world. Nitrogen serves as an innocuous diluting agent, and has no active properties of its own.

Ozone is a remarkable condensed form of oxygen, which is present in minute quantities in pure air, and especially during a thunder-storm or after a fall of snow, and in the air near the sea. In it three volumes of oxygen are condensed so as to occupy two volumes. In this condensed condition it has powerful chemical affinities; often oxidising substances which oxygen cannot attack. It is generally absent from the close air of towns and dwelling houses, having been used up to oxidise the organic matter present in these places. Air without it is said to be "devitalised." The advisability of building public institutions, and especially hospitals, in central and crowded situations, is somewhat questionable; the diminished purity of the atmosphere interfering with recovery. It is doubtful, however, whether more remote and therefore less convenient sites would always be practicable.

Ozone can be produced by hanging a piece of moist phosphorus in a room; and it is stated by Dr. Daubeny, that part of the oxygen given out by plants is in the condition of ozone. A small quantity is produced when an electrical machine is worked; its presence is evidenced by a peculiar smell (the name ozone is derived from the Greek word for smell).

Aqueous Vapour is always present in air, though the amount varies greatly. It is invisible in the ordinary condition, but by condensation becomes cloud or fog, rain, snow, or hail. The quantity of moisture present varies with the temperature of the air; the higher the temperature, the more water can be vaporised, without the point of saturation being reached. Thus the amount of moisture that would saturate the air at 50° F., would only give 71 per cent. at 60° F. The amount of moisture is estimated by the *hygrometer*. It is by far the most variable constituent of the atmosphere, but forms on an average from 1 to 1½ per cent. of its volume, that is from 50 to 75 per cent. of the amount requisite for complete saturation.

Ammonia in normal air does not exceed one part in a million of air; but it is always present—either as free ammonia or as sulphate, chloride, carbonate, or sulphide of ammonia. From this source, plants derive a large proportion of the nitrogen they require as food.

Traces of nitrous and nitric acid are also present in air, produced by the direct combination of nitrogen and oxygen occurring as the result of the electric spark during lightning.

Carbonic Acid or carbon dioxide is always present in air, in the proportion of 3·36 to 4 parts in 10,000; but in impure air may be present in much larger amount. It is a heavy gas, incapable of supporting combustion, and therefore of supporting animal life. Being a heavy gas, it tends to accumulate where it is produced, as about lime-kilns, and at the bottom of wells; and the great problem in the purification of air is to disperse it as rapidly as possible.

It is produced by the oxidation of carbonaceous matters, hence in all ordinary combustion, in many cases of putrefaction and fermentation, and in the respiratory processes of all animals.

Plants on the whole diminish the amount of carbonic acid in the atmosphere. It is a mistake, however, to suppose that they do not exhale carbonic acid. As a matter of fact two processes occur in most plants: a process of respiration, as in animals; and a process of assimilation, by which the leaves and all other green parts of a plant under the influence of sunlight decompose the carbonic acid of the atmosphere, fixing its carbon and liberating its oxygen. Plants such as fungi, which are destitute of green colouring matter, cannot decompose carbonic acid; nor can any plants during the night. It follows that during the day green plants are air purifiers; during the night all plants vitiate the air, and consequently it is inadvisable to keep them in bedrooms.

The Air in Relation to Respiration.—The oxygen of air is absolutely essential for the continuance of life. In every organised animal, *lungs* or analogous organs are provided, in order to supply the necessary oxygen to the system, and to remove the impure air from it.

The act of breathing occurs in man about seventeen times per minute. *Inspiration* is performed by the contraction of the chest muscles, which raise and evert the ribs, and so increase the horizontal space in the thoracic cavity; and by the contraction of the

diaphragm or midriff, which in contracting become less concave and flatter, and so increases the vertical extent of the chest. Air rushes into the trachea, and down to each lung to fill the comparative vacuum thus produced, and to maintain the lungs in contact with the expanded chest walls. *Expiration* is chiefly a passive act; the muscles concerned in inspiration relax; consequently the diaphragm rises, and the chest walls fall in, with the result that the air now become impure is forced out of the lungs, and through the trachea.

During the time in which the inspired air is in contact with the lungs, it undergoes important alterations. To understand these, it is necessary to enter briefly into the structure of the lungs. The trachea or windpipe, entering the chest, divides into two branches—one for each lung. These divide in a forked manner in every direction, and the ultimate branches end in minute cavities, called air-cells or air-vesicles. It has been estimated that there are at least five or six millions of these air-vesicles, having an aggregate area of ten to twenty square feet; some place the figures higher than these. Each of the air-vesicles has extremely thin walls, so delicate that their existence has even been doubted; and outside these delicate walls lie capillary blood-vessels, full of impure blood. An active interchange now occurs between the air and the gases dissolved in the blood. Oxygen passes through the intervening membrane into the blood, while carbonic acid and other impurities of the blood pass into the air-vesicle. The consequence of this is that the impure dark-coloured blood becomes bright scarlet and pure. This purification is not confined to any

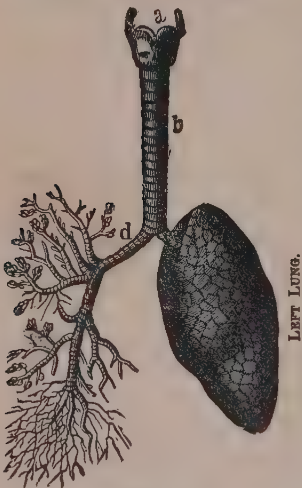


FIG. 12.

DIAGRAM OF THE RESPIRATORY TRACT.
a—Larynx; *b*—Trachea; *d*—Right Bronchus, dividing into numerous branches; Left Lung left intact.

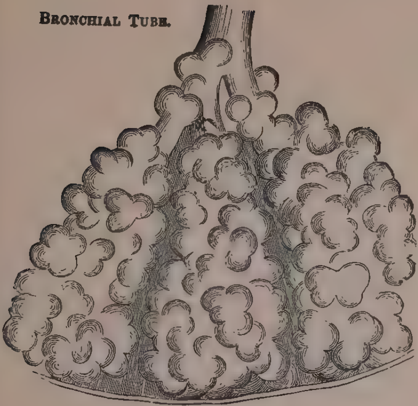


FIG. 13.
Shewing the dilated extremities (infundibula) at the ends of three minute bronchial tubes, with the air-vesicles bulging out on their walls.

one portion of the blood; for the heart contracting 60 or 70 times per minute, pours successive portions of blood into the capillaries surrounding the air-vesicles; while at the same time, pure air is brought into the air-vesicles seventeen times per minute, and so the interchange is constantly kept up.

It will be evident, from the incessant character of respiration and circulation, that all the blood will be purified if the external air is pure, and that if there is any poison or detrimental matter in the air, there is little or no chance of its not coming in contact with the blood in the lungs.

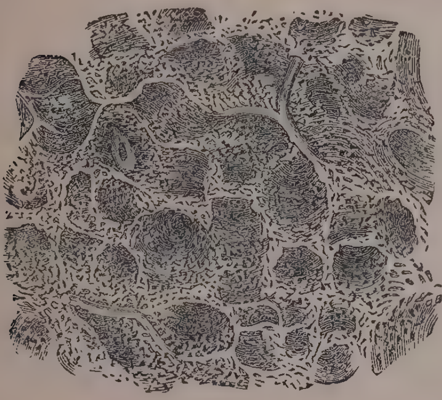


FIG. 14.
Shewing the network of minute capillaries spread on the air-vesicles of the lungs.

The amount of air taken in with each inspiration is about thirty cubic inches. This is called the *tidal air*, as it is constantly ebbing and flowing from and to the lungs. By means of a very forced inspiration, about 100 cubic inches of additional air can be inspired; and similarly after an ordinary inspiration, one can

expire forcibly an additional 100 cubic inches, though there will still be left in the lungs another 100 cubic inches of air. Thus :—

Tidal Air	30 cub. in.
Complemental Air	100 ,,
Supplemental Air	100 ,,
Residual Air	100 ,,
Total capacity of Lungs	330 ,,

Corresponding to the respiratory changes in the lungs, there are changes in the tissues throughout the body. The pure and oxygenated blood leaving the lungs, is carried to all parts of the system. Oxidation and allied processes are actively carried on, the result of which is the formation of urea, carbonic acid, and smaller quantities of other effete matters. These are then carried by the blood to the excretory organs, urea being chiefly eliminated by the kidneys, and carbonic acid by the lungs.

Examination of Expired Air shews :—1. That it is *heated;* in its passage through the blood it has acquired a temperature approaching that of the blood.

2. Its *moisture* is increased. By the skin and lungs from 25 to 40 ounces of water pass off in the twenty-four hours ; the relative amount varies somewhat. Dr. de Chaumont has estimated that 2,000 people, during two hours, the time of an ordinary concert or service, would give off 17 gallons of water from their lungs and by perspiration, and nearly as much carbon (in the form of carbonic acid) as would be contained in 1 cwt. of coal.

3. It contains 4 to 5 per cent. less oxygen, and *4 per cent. more carbonic acid* than inspired air. The carbonic acid, instead of being 4 parts in 10,000 of air, becomes over 400 in 10,000, while the oxygen is diminished in a somewhat larger proportion. Thus :—

	Oxygen.	Nitrogen.	Carbonic Acid.
Inspired air contains	20·81	79·15	·04
Expired ,, ,, ...	16·033	79·557	4·38

The *amount* of carbonic acid expired varies under different circumstances. It is increased by active work, by an increase of food, by a diminution of the external temperature; it is greater when the surrounding air is pure, and when it is moist; and it varies with the season, being greatest in spring, and least in autumn.

Children require more oxygen, and expire more carbonic acid than adults, weight for weight. A child six or seven years old requires nearly as much oxygen as one twice that age.

The average amount of carbonic acid eliminated by a healthy adult is at least 0·6 cubic foot per hour, or 14·4 cubic feet per day. This reckoned as carbon is equivalent to 160 grains per hour, or half a pound of carbon in the twenty-four hours. Liebig gives the amount of carbonic acid expired as 0·79 cubic foot per hour, or 19 cubic feet per day.

4. It contains *organic impurities.* These are probably partly gaseous, and partly suspended, the latter being particles of epithelium, fat, and putrescible nitrogenous substances. It has been estimated that about 30 grains of organic matter are eliminated from the lungs in twenty-four hours.

CHAPTER XV.

SUSPENDED IMPURITIES OF AIR.

Nature of Suspended Impurities, Organic and Inorganic.—The Impurities Inhaled in Various Occupations.—Hay Asthma.—Contagious and Septic Diseases.

Pure air being essential to life and health, it is important to ascertain the character and origin of the impurities of air. Innumerable substances—in the condition of gases, vapours, or solid particles—constantly pass into it, and tend to deteriorate its quality. To counteract this tendency, certain purifying agencies are at work, the mechanism of which will be considered hereafter.

Impurities are much commoner and more abundant in the air of enclosed spaces than in the external air, as the natural processes of

purification cannot be brought to bear so efficiently in the former case. In sick rooms, hospitals, etc., impurities arise, which are not present where only healthy people are collected. The most important impurities are derived from the respiration of animals, and the combustion of gases, candles, or lamps in rooms, from sewage emanations, from various occupations, and the air of marshes, mines, church-yards, etc. These may be classed under two heads—*solid* and *gaseous;* the solid being simply suspended in the air in a finely divided condition, or floated about in a coarser condition by currents of air. They are revealed in an atmosphere in which one did not previously suspect their existence, by the passage of a beam of sunlight. Light itself is invisible, but its course is rendered visible by the particles from which its rays are reflected. Professor Tyndall has applied this fact to the discovery of the presence of disease germs in the atmosphere.

Suspended Matters are *mineral* or *organic*, the two being commonly associated together. The **mineral matters** consist largely of fine particles of common salt, silica, clay, iron rust, dried mud, chalk, coal, soot, and similar substances. Not uncommonly the mineral particles are coated by, or mixed with, organic matter, and it would seem as though the comparative lightness of the organic matter enables the mineral matter to float about more easily. The objection to dust is thus intensified, for not only is it irritating to the respiratory passages and generally disagreeable, but it carries with it putrescent and morbific particles, often in a most active and virulent condition.

Organic Suspended Matters in the **open air** are, most commonly, minute fragments of wood and straw, dried horse litter, fragments of insects, the spores and pollen of plants, and microscopic plants and animals. In addition, there is the putrescent organic matter resulting from respiration.

Dr. A. Smith took a bottle holding five litres of air, and containing a little distilled water, and after drawing through it, by means of an aspirator, a quantity of Manchester air equal to 500

times the size of the bottle, he examined the water by microscopic powers, varying from 120 to 1,600 diameters.

The bodies seen were particles of vegetable tissues; fragments of vegetation, such as hay, straw, and hay-seeds; the hairs of plants, and fibres resembling flax; cotton fibres; starch granules; wool, white and coloured; and, most abundant of all, fungoid and lichenous matter, spores and sporidia, varying from $\frac{1}{10000}$ to $\frac{1}{50000}$ of an inch in diameter. Under each field of the microscope, over 100 spores were visible. In each drop of liquid there were over 250,000; the whole quantity consisted of 150 drops; so that there were in this water not fewer than 37½ million spores visible to a magnifying power of 1,600 diameters. The amount of air which was drawn through the bottle, was equal to that respired by an average active man in ten hours; the dangers from such spores, if any capable of producing disease are present, are very great.

Indoors, the air commonly contains, in addition, fragments of cotton, linen, silk, or other fibres, fragments of vegetables, starch cells, soot, charred wood, splinters from floors, etc.

In Sick Rooms, products of the morbid conditions may be evolved; thus, pus-cells, particles from the expectoration, blood cells, fat particles, epithelium, etc. Often the poisons of specific diseases are diffused in the air, probably as minute suspended matter. It is possible also, that the bacteria of consumption and various septic diseases, may be carried from one individual to another by the atmosphere.

Flies and other winged insects are important auxiliaries in the diffusion of such disease-carrying particles. Receiving some morbid secretions on their limbs, or other parts of their bodies, they have occasionally been the means of spreading erysipelas in hospitals, and glanders in veterinary stables. Moreover, their excreta which are not uncommonly deposited on food, or on articles of furniture, have occasionally been found to contain the minute ova of intestinal worms; and it is possible that, in this way parasitic disease is occasionally acquired.

Effects of Suspended Matters.—The inhalation of dust from whatever source is followed by deleterious effects. We may divide the solid substances inhaled as dust into three kinds:—dead substances, living substances, and the contagia of various diseases.

1. **Dead Substances** inhaled for a prolonged period in various occupations are a common cause of premature death. The *potter* draws into his lungs a fine silicious dust, which irritates his lungs, and finally produces a very fatal disease, known as **potter's asthma.**

Mill-stone Cutters and **Stone Masons** inhale the fine particles of stone given off from the material which **is** being chiselled. Ultimate destruction of the lungs results.

Pearl Cutters inhale fine particles of pearl-dust, and as they generally work in close rooms, and the dust is light and tasteless, serious disease of the lungs results. The organic part of the pearl also gets into the circulation, and, being carried to the ends of bones, produces inflammation and symptoms resembling acute rheumatism.

Sand-paper Makers inhale minute portions of glass and sand; and **needle and knife grinders** are exposed to similar dangers, and at one time the mortality among them was frightful. It has greatly diminished since the introduction of wet grinding, the use of steam fans, and wearing of respirators.

Hemp and Flax Dressers inhale a dust which is peculiarly irritating; and so fatal is the result, that if a girl of eighteen commences with this work, and is regularly employed, she nearly always dies of consumption before reaching the age of 30 years. **Workers in rags and in wool** suffer in like manner from dust. The dust from fleeces of wool, and especially from the alpaca fleece, has produced in many cases (in the neighbourhood of Bradford and elsewhere) an acute disease proving fatal in a few days. There is strong reason for regarding this as identical with malignant pustule (or the splenic fever of animals); the specific germs of this disease being inhaled as dust from diseased hides.

The **miller** commonly suffers from a form of asthma, not so severe as potter's asthma, as the particles in this case are not equally irritating. The **hairdresser** is liable to inhale the short fragments of hair cut by the scissors, and the mortality of this class of workers is decidedly above the average. **Miners** are frightfully subject to lung diseases, and, as a rule, die prematurely from bronchitis and pneumonia, due to the dust they inhale. The lungs are made dark and hard in texture by the particles of coal, which also excite a large overgrowth of fibrous tissue, as in many other cases of inhalation of foreign particles. The only exception to the rule is among the colliers of Durham and Northumberland, where the mines are well ventilated.

The Fur-dyer is very prone to suffer from the dust of the dyed furs, great irritation and disease resulting in many cases.

Artificial Flower-makers, and those engaged in colouring arsenical wall-papers, suffer from the inhalation of arsenical vapours, as well as from its absorption by the skin. Sooner or later the arsenic is absorbed into the circulation, and produces weakness, diarrhœa and vomiting, thirst, and occasionally nervous symptoms; in addition to smarting of gums, eyes, and nose, from local absorption, and small ulcers on exposed parts of the body.

Cigar-makers are liable to have their lungs irritated by inhalation of the dust of the tobacco-leaf; and in addition, the nicotine of the tobacco, becoming absorbed into the system, commonly produces muscular weakness, irregular and intermittent action of the heart, and general failure of health. Some persons are much more tolerant of the poison than others.

Workers in Lead are very liable to be poisoned by the metal; thus, house painters, potters engaged in the glazing process, in which the ware is dipped into a solution containing lead, manufacturers of white lead, and others, are commonly affected. The lead is partly absorbed by the skin; in some cases it is inhaled, either as dust or along with the fumes of turpentine; and frequently it is swallowed, from the workman eating his meals

with unwashed hands. The symptoms have been already named; "painter's colic" and "drop-wrist" are the two most important, though, in some cases, lead shews its effects more insidiously, leading to gout and chronic renal disease.

Brass-founders occasionally inhale the fumes of oxide of zinc, and diarrhœa, cramp, waterbrash, and other troubles are the result. Those engaged in the manufacture of **bichromate of potass**, are liable to partial destruction of the mucous membrane of the nose, and to irritation of the skin, with the formation, in some cases, of small ulcers.

Workers with Phosphorus, as those engaged in the making of phosphorus matches, not uncommonly suffer from a gradual necrosis (death) of the jaw-bone, which produces great deformity. Those having carious teeth are especially attacked by this disease, which is due to the fumes of oxide of phosphorus, evolved in the process, attacking the jaw. Improved ventilation of workshops, careful attention to the teeth, and other measures, have greatly diminished this disease; and it has almost disappeared since the introduction of red non-volatile phosphorus, in place of the yellow variety.

Chimney Sweeps occasionally suffer from irritative skin diseases, as well as bronchitis. In some cases the chronic irritation of the soot has produced a cancer of the skin.

Since the investigation of the above dust diseases, means have been taken to diminish their prevalence, in several cases with remarkable success. In the case of steel-grinding, for instance, it has been found that the mortality varies according to the amount of water used on the stone—being greatest with dry grinding, and least with **wet grinding.** Wet processes have been applied to others of the industries named, with a like success. Where the dust cannot be avoided, the use of **steam-fans**, to deflect the dust away from the workman, has been found successful; and in many cases, **free ventilation** of the workshops has greatly diminished the mortality. Where none of the above measures

suffice, the use of **respirators** ought to be insisted on. These are made of various materials; Mr. Baker, an inspector of factories, has invented a crape mask, which answers well. Breathing through the nostrils ought to be carefully maintained, as thus the dust is to a large extent stopped before reaching the lungs; and unnecessary conversation, involving breathing through the mouth, ought to be discouraged.

The dangers of lead poisoning may be avoided by absolute **cleanliness.** The hands ought always to be washed before taking meals, and the mouth rinsed out with water containing a trace of sulphuric acid. It is a useful practice, among the workmen in some lead factories, to make a beverage by dipping a straw into strong oil of vitriol, and then soaking it in a gallon of water. The weak acid liquid forms an insoluble and harmless sulphate of lead, which passes through the alimentary canal without being absorbed.

The dangers from the fumes of quicksilver and phosphorus are much more difficult to avoid. In the case of phosphorus, the substitution of the red for the yellow variety has removed the difficulty. But no means have yet been discovered for preventing the noxious effects of mercurial fumes.

2. **Living Substances.**—The pollen of plants in some persons produces a distressing form of disease, called **hay-asthma**, which is apt to recur each year, and is sometimes only curable by living in a town or removing to the sea-coast. The amount of pollen floating about in the atmosphere is considerable; 95 per cent. of it is grass-pollen, and this form and the pollen from pine-trees appear to be the most powerful in inducing hay-asthma. According to some authorities, hay-asthma is rather due to the minute particles constituting the scent of various flowers, than to the pollen; but this is probably not the usual mode of origin of the disease, though it may be in some cases. In some cases, true asthma results from smelling particular plants. Here as in the case of hay-asthma a peculiar idiosyncrasy is involved, only a very small

proportion of those exposed to the minute particles being affected by the morbid condition.

The spores of many fungi and of other living organisms are constantly being floated about in the air, until they find a suitable resting place, when they settle and proceed to grow and multiply. The souring of milk, the fermentation of a saccharine solution, the moulding of bread, the presence of mildew, the blighting of corn, and numerous other phenomena are due to the growth of organisms carried by the atmosphere from one part to another.

3. **The Contagia** of the specific diseases, are probably living organisms, but it is convenient to class them under a separate head. Nearly all the specific fevers may be propagated through the air, though some much more easily than others. The exact condition in which these contagia exist in the atmosphere is doubtful, but there are strong reasons for regarding them as microscopic organisms, which float about alone or along with particles of epithelium or pus cells or putrescent organic matter, until they find a suitable "soil" in which to develop. Some of these contagia have a persistent vitality, resisting oxidation for a considerable time, as is the case with the poisons of scarlet fever and small-pox. They may infect the air of a room for weeks, and in this respect they resemble other low forms of animal and vegetable life, which may be dried for years and yet recover their vitality when moistened. The poisons of typhus fever and of the Oriental plague, on the other hand, are easily destroyed by free ventilation. Malarious poison may be carried by winds for a considerable distance, unless a surface of water or a belt of trees intervenes; and in some cases a similar carriage of cholera seems to have occurred, though this is uncommon.

Besides the contagia of the specific fevers, *septic organisms* may be carried by the atmosphere. Formerly, blood-poisoning from operation and other wounds was frightfully common; but Professor Lister introduced the antiseptic system of dressings, by means of which the air having access to the wound was filtered through layers of

carbolised gauze and deprived of its septic germs; with the result that wounds can now be kept perfectly "sweet," the suppuration in them is reduced to a minimum, and the danger of blood-poisoning is almost annihilated. It had often been noticed that recovery from even very severe injuries was common, if only the skin remained unbroken; while the same injuries, with the addition of a rupture of the skin, and consequent access of air, were rapidly fatal. But to Lister is due the great honour of proving that it was not the air which produced the mischief, but the germs it contained, and that filtered air might be admitted with impunity.

Erysipelas and *hospital gangrene* are occasionally carried about in hospital wards by dirty sponges and dressings; and if the ventilation is not perfect, particles of epithelium and pus from the diseased persons may be carried to other patients at a distance. Some forms of *purulent disease of the eyes* are transferable from patient to patient, and in children some forms of *eczema* are also contagious. In these, however, it is probable that actual contact is necessary.

CHAPTER XVI.

GASEOUS IMPURITIES OF AIR.

Effects of Inhalation of Carbonic Acid, Carbonic Oxide, and other Gases and Vapours.—Air rendered Impure by Respiration.—Coal-Gas and its products.—Emanations from the Sick.—The Air of Sewers, etc.—Effluvia from Decomposing Organic Matter.—Extremes of Moisture or Temperature.

Gaseous impurities of the air are very commonly associated with suspended matters, and it is in many cases difficult or impossible to separate the effects of the two.

Different gases are also often associated, and so produce modified results. It will be convenient to consider, first of all, certain well-marked gaseous impurities, and then others in which there is a mixture of several gases, or of these with suspended solid particles.

Under the first head the most important impurity is—

(1) **Carbonic Acid.**—This is reckoned an impurity if amounting to more than 5 parts in 10,000 of air. Owing to the large amount produced in the respiration of animals, in the combustion of fires, gas, lamps, etc., and in other natural processes, it would be much greater in populous parts, were it not for the rapid diffusion occurring in the air, and the purifying action of plants. The following analyses from Dr. Angus Smith's work on "Air and Rain," illustrate the facts that in towns the amount rises, and is greatest in the most populous parts, while during fogs it is greatly increased.

	VOLUMES OF CARBONIC ACID IN 10,000 VOLUMES OF AIR.
On the mountains and moors of Scotland—mean of 57 analyses	3·36
In the streets of Glasgow—mean of 42 analyses	5·02
London, N., N.E., and N.W. postal districts—mean of 30 analyses	4·384
London, E. and E.C.—mean of 12 analyses ...	4·745
Manchester streets, ordinary weather	4·03
During fogs in Manchester	6·79

The effects of carbonic acid gas alone must be carefully distinguished from those of the same gas *plus* the organic impurities from respiration, with which it is commonly associated. Dr. Angus Smith found that air containing 3 per cent. of carbonic acid produced difficulty of breathing, but he was able to breathe comfortably an atmosphere containing 0·2 per cent. carbonic acid. Other observers have found they could breathe without discomfort air containing 1 per cent. carbonic acid. When the carbonic acid is derived from respiration, headache and giddiness are produced in many persons when the carbonic acid amounts to 0·15 per cent. A fatal result has occasionally occurred from the inhalation of the carbonic acid at the bottom of wells, or of brewing vats, or about limekilns.

The presence of an excess of carbonic acid probably retards the elimination of carbonic acid from the lungs; the consequence is that general nutrition is impaired, and muscular energy fails. This is seen in workshops where the air is confined and gaslight is commonly employed; though the air here also contains carbonic oxide, sulphurous acid, and organic impurities, and these probably have a large share in producing the evil results.

(2) **Carbonic Oxide** in the proportion of more than 1 per cent. is rapidly fatal, and has poisoned when under ½ per cent. Poisoning by its means occurs chiefly where charcoal stoves are used, and especially when the charcoal is burnt in rooms with no chimney flue. This is an occasional mode of suicide on the continent. Carbonic oxide is a much more deadly poison than the dioxide (carbonic acid); it forms a stable compound with the hœmoglobin of the red blood-corpuscles, which displaces oxygen from them, and is got rid of with great difficulty. Lace-frame makers place a coke stove under their work, and thus inhale the invisible gas. Headache, giddiness, irregular action of the heart, and depression of the general health result.

(3) **Sulphuretted Hydrogen** occasionally seems to produce troublesome symptoms, such as headache, nausea, and diarrhœa; but many persons engaged in manufactures involving the evolution of this gas seem to escape.

(4) **Sulphurous Acid** is always present in small quantities in the air of towns, derived from the combustion of coal and gas. Straw-bleachers and the bleachers in cotton and worsted manufactories, often suffer from severe cough and bronchitis from inhaling its irritating vapours.

(5) **Carbon Disulphide** when vaporised and inhaled produces headache, general muscular pains, nervous depression, and even worse symptoms. It is used in the manufacture of vulcanised india-rubber, toy-balloons, etc.

(6) **Ammonia** produces irritation of the eyes and bronchial irritation. Hat-makers commonly suffer from its effects, being

generally pale and feeble. It is difficult to say how much is due to the ammonia, and how much to the necessarily high temperature at which they work.

(7) **Acid Fumes** are very irritating to the lungs, and in the case of alkali manufactures, they destroy all vegetation for considerable distances. *Hydrochloric acid* produces great irritation, and chlorine even more so. The fur-dyer is not only subject to the dangers of dust, but also of the fumes of *nitric acid*, used to remove fat and give certain shades of colour to the fur.

(8) **Other Vapours** evolved in various processes produce special symptoms. Photographers suffer from depression, giddiness, etc., due to the fumes evolved by *cyanide of potassium*. This is now largely abandoned, and hyposulphites have taken its place. House-painters suffer from the inhalation of *turpentine vapour*, headache and loss of appetite commonly resulting. The symptoms from the commonly coexistent lead-poisoning are distinct. Brush-makers have a persistent suffocative cough, the result of the inhalation of *resinous fumes*, evolved in making brushes.

Workers in paraffin are liable to an irritative disease of the hair-follicles of the body, followed by the formation of scars, almost like smallpox marks.

Workers in quicksilver, as those engaged in making mirrors or thermometers, are prone to suffer from mercurial poisoning. The gums become spongy, and there is profuse salivation, also generally alimentary disturbance; and in some cases nervous affections, resulting in persistent muscular tremblings, etc.

Under the second head—cases of inhalation of mixed gases, often of a doubtful constitution—we must consider

(1) **The Effects of Air Rendered Impure by Respiration.**—It has been already stated that an amount of carbonic acid which could easily be borne alone, is intolerable when other products of respiration are mixed with it. These are chiefly organic gases and solids, which (unless removed quickly) render the atmosphere close and "stuffy"—an effect which is readily perceptible by the sense

of smell of those entering an occupied room immediately from the outer air. When such a room is inhabited for a few hours, headache, languor, drowsiness, and yawning (which is really a cry for purer air) result. The soporific effects so commonly produced in churches, etc., are commonly due to the vitiated atmosphere, rather than as is supposed to the soothing effects of the sermon. After leaving a room of the above description and retiring to the bedroom, the previous drowsiness is succeeded by a wide-awake condition, due to the colder and fresher air inhaled.

When the exposure to foul air is *more chronic*, and occurs day after day, there results a general lowering of strength and vigour—both bodily and mental—even where no actual disease is set up. Oxidation processes are retarded; the consequence is an anœmic sallow complexion, which compares badly with the ruddy complexion of those spending a great part of the day out of doors.

The prolonged breathing of air, foul from the products of respiration, is perhaps more common in workshops and schools than in private houses; but in both, a faint smell is commonly perceptible on entering from the open air, speaking of imperfect ventilation and accumulation of organic putrescible matter.

The **tendency to catarrhs** is greatly increased by living in a vitiated atmosphere. A "cold" most commonly results on leaving a vitiated atmosphere, which has disordered the nervous system, and rendered its control over the circulation in the skin and internal organs incomplete. It seldom or never arises from cold weather *per se*. This was abundantly proved by the experience of the British army in the Crimea. When the soldiers lived in tents in the most severe weather, colds were unknown; but when some of the men were put in huts, in which the air was warmer and not so freely renewed, the sick rate increased, and colds and coughs became common.

The close connection of **phthisis** (consumption) with overcrowding and the breathing of a vitiated atmosphere, will be

discussed hereafter. The polluted air in producing consumption probably acts by depressing the vital functions, and by inducing a tendency to degenerative changes and the development of lowly organised growths, as well as by favouring the propagation of the disease from individual to individual.

The germs of contagious diseases are propagated very rapidly in an impure atmosphere; and typhus fever seems under some conditions to be produced by overcrowding.

In the cattle-plague of 1866, it was found that nearly all the cows died when crowded together in unventilated sheds, while only a third died when there was free ventilation.

The effects of air containing the products of respiration in a *concentrated condition*, has been shewn only too well in the oft-quoted case of the Black Hole of Calcutta. In this case, 146 persons were confined in a space eighteen feet every way, with two small windows on one side. Next morning 123 were found dead, and the remaining 23 were very ill.

Speaking generally, it is found that the average death-rate in this country increases in the same ratio as the density of the population. The death-rate from phthisis, child-birth, and typhus fever, for instance, is far higher in cities than country places. This may be explained in various ways. Density of population commonly implies insufficient or unwholesome food, unhealthy work, and poverty; but especially impurity of the air, uncleanliness, and imperfect removal of excreta. Of these factors, the vitiated air is probably the most powerful for evil. It has been observed that children's diseases are twice as fatal in towns as in rural districts. According to Sir T. Watson, town children get as much exercise as their time of life would allow anywhere, and one is bound to infer that the vitiated atmosphere is the main cause of the difference.

(2) **Coal-gas** consists of a mixture of various gases, as shewn in the following analysis from Parkes:—

Hydrogen	40 to 45·58
Marsh gas (CH_4)	35 to 40
Carbonic oxide	3 to 6·6
Olefiant gas (C_2H_4)	3 to 4
Acetylene (C_2H_2)	2 to 3
Sulphuretted hydrogen	0·29 to 1
Nitrogen	2 to 2·5
Carbonic acid	3 to 3·75
Sulphurous acid	
Ammonia or ammonic sulphide ...	·5 to 1
Carbon disulphide	

The inhalation of coal-gas, even in small quantities, is liable to produce headache, and may lead to chronic poisoning if allowed to continue. Where the escape of gas is more extensive, as when a tap is left turned on accidentally during the night, two dangers may arise. If a light is struck in the room, an explosion occurs; or persons may be poisoned in their sleep by inhalation of the gas.

The products of the combustion of coal-gas are likewise deleterious. It is found that one cubic foot of coal-gas consumes the oxygen of eight to ten cubic feet of air, and produces about two cubic feet of carbonic acid. A medium gas-burner therefore, which burns about three cubic feet of gas per hour, destroys twenty-four cubic feet of oxygen, and produces six cubic feet of carbonic acid. These six cubic feet of carbonic acid ought to be contained in more than 10,000 cubic feet of air, instead of in an ordinary sized room. The necessity for a frequent change of air will consequently be evident.

Two hard candles or one good oil lamp produce the same amount of carbonic acid as a man; while a medium gas-burner produces as much carbonic acid as about ten men. These data will help in estimating what amount of fresh air is necessary in an enclosed space per hour, in addition to that required for removing the impurities produced by respiration.

For equal illuminating power, candles give more impurity to the air than gas; but one is commonly content with a smaller and more localised light from candles or lamps than from gas. Besides carbonic acid, minute quantities of carbonic oxide, sulphurous acid, sulphuretted hydrogen, ammonia, &c., are produced by the combustion of coal-gas, and all these produce injurious effects. The ill effects of living in an atmosphere polluted with the products of combustion have been abundantly proved. A condition of general ill health, mental and physical inaptitude for work, with loss of appetite, anæmia, and other symptoms, are produced.

(3) **Air Rendered Impure by Exhalations from the Sick.**—In the case of the specific fevers, infection almost certainly results from breathing the polluted atmosphere, and the aggregation of numerous cases of the same fever always increases the danger. Erysipelas and septicæmia (blood poisoning) have until recent years been frequently spread in hospital wards; and there can be no doubt that the aggregation of cases of suppurating wounds with decomposition has been the chief cause of this. The adoption of greater cleanliness both in the wards themselves and in the dressing of wounds, and the application of antiseptic principles (whether according to Lister's method or otherwise) have led to a wonderful improvement in these respects; and now the mortality of hospital patients does not compare very unfavourably with that of patients treated in private houses. Hospital gangrene, formerly very common, now rarely occurs. It can be avoided by free ventilation; and is hardly ever seen when wounded soldiers are treated in tents.

The air which consumptive patients breathe, ought to be avoided as far as possible, and free ventilation insisted on. The cases of actual carriage of consumption by the breath from one person to another, must however be very rare, and probably only occur when the healthy and diseased have slept together. (See also under solid impurities, *page 154;* emanations from the sick are both gaseous and suspended).

(4) **The Air of Sewers, Cesspools, etc.,** usually contains the

products of decomposition of sewage, such as volatile fœtid organic matter, carbo-ammoniacal substances, sulphuretted hydrogen, carbonic acid, etc. The amount of these various products varies greatly under different circumstances, such as dilution of the sewage, ventilation of sewers, temperature, etc. The chief danger of sewer-gas appears to lie in the organic matters it contains. These probably do not become scattered in the atmosphere until gas is developed in the sewers; then the slow effervescence throws particles of liquid into the air which may be transmitted through considerable distances by gentle currents. (Frankland) Dr. Parkes, reporting on an epidemic of cholera at Southampton, shewed similarly that sewage in passing through untrapped drains may froth, and that the bubbles may throw spray a long way into the air, rendering it infectious. These observations serve to impress the practical lesson that the danger of sewage is in proportion to its stagnation. If it is hurried away before time is allowed for putrefaction, the danger is reduced to a minimum.

The exhalations from cesspools or privies on cleaning them out, may produce severe disorders, which are sometimes fatal. When a drain is newly opened or sewer gas gets into a house, a less marked form of poisoning commonly results, chiefly characterised by languor, headache, vomiting, and diarrhœa. In some cases there may be febrile attacks lasting a few days. Children are especially sensitive to such conditions and quickly fall into ill health.

The emanations from *obstructed* drains are especially to be feared. It is doubtful whether the air of unobstructed sewers is dangerous; statistics concerning sewer-men seems to prove the opposite; but the enquiry has not been very thoroughly carried out. Probably much depends on the ventilation of the sewers.

The presence of healthy fæcal matters undergoing fermentative changes is competent to produce the non-specific disorders already mentioned; but under some conditions specific diseases are produced by sewer-gases.

Erysipelas and puerperal (childbirth) fever have been proved to

be occasionally due to sewer emanations, and many lives have been lost from these causes.

Diphtheria is in many cases due to emanations from sewers, either directly inhaled, or perhaps more commonly received after having been absorbed by water or milk. Ulcerated sore-throat has in some cases been distinctly traced to sewer-gases. Summer diarrhœa may also be due to sewer-emanations directly inhaled, or taken in drinking water. It is worst in badly drained districts, and when there is a dry season, with the thermometer persistently above 60°.

Typhoid fever is due to the effluvia from drains, but whether these must be of a specific character (derived from a previous case), or whether putrefactive changes alone, under certain conditions of temperature, etc., will produce it, is still an open question. Dr. Murchison, one of the greatest authorities on the subject, has adopted the latter view, and has proposed for typhoid fever the name "pythogenic fever" (*i.e.*, filth-produced). Isolated cases of typhoid, occurring where there is no system of drainage, support the same view, as does also the fact that, with the adoption of drainage, the typhoid mortality has steadily diminished. In twenty-one English towns, the average reduction of typhoid mortality after drainage was 45·4 per cent. But if typhoid fever is due to emanations from putrefied excreta, one would expect it to be very common. On the other hand, numerous cases can be quoted to shew that such emanations have been breathed, and sewage-contaminated water drunk, for years, without the production of a single case of typhoid—until a case is accidentally imported. On the whole, the somewhat conflicting evidence supports the view that typhoid fever is most commonly due to a specific cause—*i.e.*, arises from a previous case; though the possibility of its origin without any such specific cause cannot in the present state of our knowledge be denied.

In addition to the diseases already named, the poisons of cholera and yellow fever may exist in sewer air; possibly also

those of small-pox, scarlet fever, etc., as well as of dysentery and diarrhœa.

(5) **Effluvia from Decomposing Organic Matter.**—(*a*) **The air of marshes** contains an excess of carbonic acid, marsh gas, etc., in addition to other organic matters. Intermittent and remittent fevers are due to the inhalation of the marsh effluvia under certain conditions. Some forms of diarrhœa and dysentery have been ascribed, with a less degree of certainty, to the same cause. In this case, as in that of emanations from other organic sources, the impurities received by the air are both gaseous and particular.

(*b*) **The Air of Graveyards** has occasionally produced disease. In other instances where no actual disease has resulted, it has been found that in the neighbourhood of thickly crowded graveyards, the sick-rate and death-rate have been increased.

(*c*) **The Effluvia from Decomposing Carcases**, especially of horses on the battle-field, have led to outbreaks of diarrhœa and dysentery among the soldiers.

(*d*) **The Effluvia from Manure and Similar Manufactories** do not seem to injure the workmen as a rule, but attacks of diarrhœa have been produced in the neighbourhood when the wind has wafted the effluvia towards any particular part.

(6) **The Effluvia from Certain Manufacturing Processes** seem to be rather nuisances than actually productive of ill health. The vapours given off by *tallow-making* and *bone-burning* processes are most disagreeable, but there is little or no positive evidence of their insalubrity.

The air of *brickfields* and cement works is peculiarly disagreeable, but nothing more than a nuisance has been established in the numerous trials regarding these.

The Degree of Moisture and the Temperature of air are of great importance in relation to health. Air which is unduly moist or dry, hot or cold, may be injurious apart from any foreign matters it contains.

The *relative amount of moisture* is of greater importance than its

actual amount. An atmosphere which contains aqueous vapour up to the point of saturation is very oppressive; the normal evaporation of insensible perspiration (and with it of the organic impurities removed from the skin) is interfered with; and consequently the "oppressiveness of the day" is complained of.

It is a common fallacy to suppose that the windows of a room must be kept closed on a wet day, "to prevent the damp getting in." If the temperature of the room is moderately high, there is no fear of making the air damp. Damp air is only dangerous when the point of saturation is nearly reached; and it is in such conditions that rheumatism commonly develops. Washing and drying linen in bed-rooms, which is common among poorer people, is very objectionable because of the damp induced; and for a similar reason the frequent washing of floors, unless there is free ventilation, is not desirable. If the floors are of wood, they may sometimes be stained and varnished; and in other cases damp may be avoided by choosing a dry day for cleaning, and having free ventilation afterwards.

It is stated that the prevalence of catarrhs in the United States of America (as well as, possibly to some extent, the nasal manner of speech) is largely due to the exceeding *dryness* of the atmosphere. The nasal articulation is, however, chiefly hereditary.

An unduly hot air is generally productive of pallor and ill health, though it is difficult to know how much to ascribe to the high temperature, and how much to the commonly co-existent vitiated atmosphere. The temperature of living-rooms ought not to be over 60° to 65° Fahr., and of bed-rooms not over 60° Fahr.

A hot air is commonly also a dry one; and the combination is very distressing. This is seen where closed stoves are employed for heating rooms. The discomfort may be removed by having a pail of water standing near the stove.

The devitalising influence of extreme *cold* is well known. Its effects are more particularly seen in young children and the very old. The obituary column of the "Times" is generally crowded

with notices of the deaths of old people, after a few days' severe frost. Dry, cold weather, with the temperature near the freezing point of water, and a cutting east wind prevailing, is not uncommonly described as "bracing." This is so far from being the case, that it requires all the vital powers of the strong and healthy to resist its depressing influence, and the feeble of both extremes of age succumb.

CHAPTER XVII.

THE EXAMINATION OF AIR.

Examination of Impurity by the Senses.—Chemical Examination.—Estimation of Carbonic Acid, etc.—Organic Matter.—Microscopical Examination.—Examination of Moisture and Temperature.

It is important to be able to ascertain the quality of the air in enclosed spaces. There are various methods of doing this, of which not the least useful is the information furnished by the *sense of smell*, on entering a room from the external air. Besides the evidence given by the senses, *chemical* and *microscopical* examination of the air give important information, while the *thermometer* and *hygrometer* ascertain the temperature and degree of moisture.

Examination by the Senses.—One often sees a dull grey haze hanging over a town, when it is viewed from a distance, indicating comparative impurity of its atmosphere, and the presence of a considerable amount of suspended matter.

But the *smell* of a stagnant atmosphere is one of the best guides to its condition. The presence of even a small amount of respiratory products can be thus detected on entering a room from the external air. The sense of smell is extremely delicate; it has been estimated that the $\frac{3}{100,000,000}$ part of a grain of musk can be apprehended by it. But nothing is so soon dulled as the sense of smell. An atmosphere which did not appear to be unpleasant while remaining in a room, is intolerable when one returns to it

after a few minutes in the open air. It is important not to confound the "closeness" perceived by the sense of smell, with the oppression due to the high temperature of a room. The two are easily distinguished by a reference to the thermometer, which ought always to be placed in rooms inhabited during the evening. The remedy for a close room is to allow free entry of fresh air, and *not* allow the fire to go down, as is so commonly done, under the impression that the closeness is due to heat.

Dr. de Chaumont has made many experiments, shewing how accurate is the information given by an acute sense of smell. Carbonic acid is destitute of odour, but as its amount is usually proportionate to that of the organic matter producing closeness, it may be taken as an index of the amount of impurity present in living rooms. Dr. de Chaumont has found that the limit of smell is reached when carbonic acid amounts to 6 parts in 10,000 of air, or half as much again as in the external air. In the following extracts from his experiments, there was a close accordance between the evidence of his sense of smell and the per-centage of carbonic acid:—

At ·1408	*per cent.*	*Extremely close and unpleasant.*	*At* ·0843	*per cent.*	... *Not very foul.*
,, ·1090	,,	... *Extremely close.*	,, ·0804	,,	... *Close.*
,, ·0962	,,	... *Very close.*	,, ·0658	,,	... *Not very close.*
,, ·0921	,,	... *Close.*	,, ·0568	,,	... *Not close.*

He also found that humidity of the air had a marked influence in rendering the smell of organic matter perceptible, even more than a rise of temperature. The sense of smell is doubtless aided in detecting impurities in the air, by the *besoin de respirer*, a feeling of oppression caused by the deficiency of interchange between the blood and air.

Chemical Examination.—The estimation of nitrogen and oxygen in air is unnecessary, as these vary little, if at all. The ill effects of an often-breathed atmosphere are not due so much to deficiency

of oxygen, as to the addition of carbonic acid and organic matters, rendering difficult the interchange between oxygen and the blood. The amount of oxygen in the streets of large towns is as great as on the hill-tops in country places. Dr. Angus Smith has shewn that the lowering of oxygen in badly-ventilated places only amounts to 0·3 per cent. At the bottom of mines there is a greater diminution of oxygen than in the worst ventilated places, sometimes falling even to 18·27 per cent. (A. Smith).

The Estimation of Carbonic Acid is of great importance, as it is found that, under ordinary circumstances, its amount is an exact indication of the amount of contamination in the air. When the temperature of the air is excessive, however, the carbonic acid increases disproportionately. It has been proved, both by estimation of the organic matter in air and of that dissolved from the air by rain-water, that the amount is proportional to that of the carbonic acid, and that both carbonic acid and organic matter (separated in the form of ammonia) increase with the density of the population of a district.

In estimating the carbonic acid in air, the amount in 1,000 volumes has to be determined. A carefully dried glass vessel capable of holding a gallon, is filled with the air to be examined, which is pumped in by a bellows. 60 cubic centimetres of clear lime-water are then added, and the vessel is closed with an india-rubber cap. It is then well shaken, and afterwards allowed to stand for six or eight hours. The carbonic acid combines with part of the lime to form calcium carbonate; and the lime-water remaining is consequently diminished in alkalinity or causticity. Given the causticity of the lime-water before and after the experiment, and the difference will give the amount of lime which has combined with carbonic acid.

The causticity of the lime is estimated by a standard solution of oxalic acid, the addition of a known amount of which forms a discoverable amount of oxalate of calcium; specimens of lime-water being taken and estimated before and after shaking up with

the given air. The difference between these two shows the number of milligrammes of lime precipitated by the carbonic acid. Multiply the difference by 0·795, and the result is the cubic centimetres of carbonic acid in the quantity of air examined. The factor 0.795 is obtained from the ratio of the equivalents of quick-lime ($CaO = 56$) and carbonic acid ($CO_2 = 44$).

A certain correction must be made for temperature, the standard being 32° Fahr.; also if the place of observation is much above the sea-level, a correction must be made for difference of atmospheric pressure.

Dr. Angus Smith's plan for the estimation of carbonic acid in air is very useful, as not involving skilled manipulations or difficult calculations. It is based on the fact that the amount of carbonic acid in a given volume of air will not render turbid a given amount of lime-water, unless the carbonic acid is in excess.

EASIEST PROPOSED HOUSEHOLD METHOD.

TABLE.—*To be used when the point of observation is "No precipitate."* Half an ounce of lime water containing ·0195 gramme lime.

Air at 0° C. and 760 M. M. Barometric pressure.

CARBONIC ACID IN THE AIR. PER CENT.	VOLUME OF AIR IN CUBIC CENTIMETRES.	SIZE OF BOTTLE IN CUBIC CENTIMETRES.	SIZE OF BOTTLE IN OUNCES AVOIRDUPOIS.
·03	571	584	20·63
·04	428	443	15·60
05	342	356	12·58
·06	285	299	10·57
·07	245	259	9·13
·08	214	228	8·05
·09	190	204	7·21
·10	171	185	6·54
·11	156	170	6·00
·12	143	157	5·53
·13	132	146	5·15
·14	123	137	4·82
·15	114	128	4·53
·20	86	100	3·52
·25	69	83	2·92
·30	57	71	2·51

The foregoing table arranged by Dr. A. Smith, shews how to apply this method. The first and second columns state the ratio of carbonic acid in a quantity of air which will give no turbidity or precipitate in half an ounce of lime water; the third column gives the corresponding size of the bottle in cubic centimetres; and the fourth column gives the same in ounces. Thus different sized bottles, each containing half an ounce of lime water, will indicate with a fair degree of accuracy the ratio of carbonic acid in the air containing them, by giving no precipitate when the bottle is well shaken. For instance, if a pint bottle is used and there is no precipitate with half an ounce of lime water, it indicates that the ratio of carbonic acid does not amount to ·03 per cent.; if an eight ounce bottle be used, and there is no precipitate, it indicates that the ratio does not amount to ·08 per cent., and so on. The air of a room ought never to contain more than six parts of carbonic acid in 10,000 of air, or ·06 per cent., *i.e.*, a $10\frac{1}{2}$ ounce bottle full of the air shaken up with half an ounce of clear lime-water ought to give no precipitate.

The Estimation of Organic Impurities may be accomplished approximately by drawing a definite amount of air by means of an aspirator, through a dilute solution of permanganate of potassium of known strength. The result is stated by giving the number of cubic feet of air required to decolourise ·001 gramme of the permanganate in solution. Sulphuretted hydrogen, sulphurous acid, and other substances in air likewise decolourise the permanganate; these ought to be separately tested for, and allowance made.

The Estimation of Ammonia, whether free or derived from albuminoid impurities, is a matter requiring very delicate processes. It is accomplished in the same way as the estimation of ammonia in water, the air being drawn through perfectly pure distilled water, and then the analysis proceeded with as a water analysis. The mere presence of free ammonia may be determined by exposing to the air strips of filtering paper dipped in Nessler's solution, which become brown if there is any ammonia in the air.

Microscopical Examination is only of use in the detection of suspended matters, but as these are probably the most potent for harm, containing sometimes the germs of dangerous diseases, this method may in the future lead to valuable results. The suspended matters scattered throughout the air may be collected by Pouchet's aeroscope. This consists of a small funnel drawn out to a fine point, under which a slip of glass is placed moistened with glycerine. Both funnel and glass are enclosed in an air-tight chamber, connected by tubing with an aspirator, by means of which when water is allowed to escape from it, air is drawn through the funnel and its particles impinging on the glycerine are there arrested. Glycerine may be objectionable from the foreign particles previously contained in it. Various other plans have been devised, one of which is to draw the air through a small quantity of pure distilled water and then examine a drop of it. The drop of water may have a small quantity of gelatine added to it, and in this condition solidified. The organisms found in water may be grown in this medium and examined at leisure (Koch's gelatine process).

Examination of Temperature and Moisture.—The temperature should be observed at the point most remote from an open fire-place, and compared with the external temperature. If there is a great difference between the two, the probability of draughts is greatly increased.

The moisture may be estimated by various forms of hygrometer; wet and dry bulb thermometers are convenient and reliable. The hair hygrometer gives fairly accurate results.

It may be useful to recapitulate at this point the desiderata in an inhabited room. The temperature should be 60 – 62° Fahr., the amount of carbonic acid should not exceed ·06 per cent. and the humidity should range between 73 and 75 per cent. of the amount required to produce saturation.

CHAPTER XVIII.

THE PURIFICATION OF AIR.

Influence of Plants and of Rain.—Diffusion of Gases.—Thermo-Diffusion.—Interchange owing to Differences of Temperature. — The Two-fold Action of Winds.—Chemical Measures for Purifying Air.

In previous chapters we have discussed the various impurities to which air is subject. It is necessary that these should be removed. In addition to the artificial measures which will be discussed in the next chapter, various natural agencies are constantly at work for this purpose. Of these, the most important are the action of plants, the fall of rain, natural methods of ventilation, and certain natural constituents of the atmosphere.

1. **Plants,** by virtue of the chloropyl contained in their green parts, absorb carbonic acid from the atmosphere, liberating oxygen in an active condition. In addition, ammonia and nitrous and nitric acids are dissolved from the air by rain-water, and assimilated by plants. During the night plants only give off carbonic acid.

2. **The Fall of Rain** clears the atmosphere of any solid particles contained in it, the impurities being transferred to rain-water which generally contains an appreciable amount of ammonia as well as other impurities. It is found, however, that when the atmosphere is excessively moist, and especially when its temperature is somewhat high, the amount of organic matter contained in it is increased ; while a dry atmosphere, as a rule, contains little organic matter.

3. **Ventilation**—that is, the interchange of pure and impure air, is constantly being effected. Before entering on the details of ventilation, we must consider the *physical causes* at work which tend to purify the air, apart from all artificial contrivances. These are three in number—namely, diffusion, winds, and differences of temperature of masses of air.

(1) **Diffusion** causes the rapid mixture of gases placed together. Every gas diffuses at a certain rate—namely, inversely as the square root of its density. In any room which is not air-tight, diffusion is constantly occurring, air passing in and out at every possible point. Through chinks and openings in the carpentry-work of a room, the air diffuses rapidly. Bricks and stone commonly allow air to pass through them; diffusion occurs to a slight extent even if the wall is plastered, but very little through paper. Yet diffusion alone hardly purifies a room sufficiently under ordinary circumstances; and the organic molecular matter evolved from the skin and lungs, not being gaseous, is unaffected by it. To remove the latter, the room must be periodically flushed with air.

A peculiar form of diffusion has been described by Fedderson of Leipzig, to which it is proposed to give the name of **thermo-diffusion.** It was shewn as the result of careful experiments that when a porous partition separates two columns of air, one warm and the other cold, a passage of air from the cold to the warm side occurs. This form of diffusion is not dependent like the ordinary diffusion on the presence of gases of different density, but occurs when there is the same gas with the same pressure on both sides of the porous partition.

Diffusion sometimes produces evil results, when the sanitary arrangements of a house are bad. If there is a leakage of sewage under the kitchen-floor, the foul gases from it diffuse upwards; occasionally foul air diffuses from the dust-bin through the wall into the rooms of a house. Both these unfortunate results are helped by the fact that the internal temperature of a house is commonly higher than the external.

(2) **Differences of Temperature** cause active movements of air. In fact winds are caused by movements between large masses of air of unequal temperature and consequently of unequal density. Light gases ascend, as familiarly illustrated by the smell of dinner perceived in bedrooms, or the smell of a cigar lit in the hall perceived in the attic. In rooms differences of temperature of the

air are caused by the heat of fire, gas, and our own bodies. Currents of air result; the warmer and lighter air ascends up the chimney or towards the ceiling, while colder and denser air rushes in under the door or through the floor, etc. The lighter gases carry with them solid particles in suspension and thus tend to remove the most important respiratory and other impurities. As a rule in this country the external temperature is lower than the internal, but occasionally in summer the opposite condition occurs. Assuming that the external air is colder, if admitted into the lower part of a room, it produces a draught; if admitted at the top of a room, being heavier, it falls by its own weight on the heads of those in the room. The problem of ventilation is to secure a sufficient interchange of air without the production of perceptible currents.

Movements of air are constantly occurring, so long as the temperature of the air is subject to changes. This cause alone will suffice to ventilate all rooms in which the air is hotter than the external air. It may thus happen that a room with windows and doors closed in winter, may possess purer air than the same room in summer with these thrown widely open. The value of diffusion of air through the walls, and the influence of temperature on this diffusion are well illustrated by some experiments of Pettenkofer. When the difference between the outside and inside temperatures was 34° Fahr. (66° inside and 32° outside), and the doors and windows were shut, an ordinary room in his house, of the capacity of 2,650 cubic feet, which was built of brick, and furnished with a German stove instead of an open fire-place, had its entire atmosphere changed once in an hour. With the same difference of temperature, but with the addition of a good fire in the stove, the change of air rose to 3,320 cubic feet per hour. On lessening the difference between the external and internal temperature to 7° Fahr. (64° and 71°), the change of air was reduced to only 780 cubic feet per hour. In these experiments, all crevices and openings in doors and windows

were pasted up. It is instructive to note the proportionate amount of ventilation effected through the walls and by the draught of the stove. In the first experiment, the ventilation due to diffusion and difference of temperature equalled 2,650 cubic feet of air; that due to the draught of the stove 670 cubic feet of air.

The amount of ventilation through walls varies with the material of which they are built. Mortar is exceedingly porous when dry; sandstones and bricks are easily permeated by both water and air. Limestone is almost impervious to air, but requires much mortar in building, which effects a partial compensation.

The rise of temperature caused by the bodily heat and by the combustion of illuminating agents, is well shown by some figures of Dr. Angus Smith. He found that the rise of temperature of 170 cubic feet of air in one hour, by the bodily heat of one man was 5°·6 Fahr.; by the combustion of a candle 3°·8 Fahr. Thus, in a room 8 feet high, 4 feet broad, and 6 feet long, a man burning a candle would in an hour raise the temperature from 60° to 70° Fahr. This rise in temperature would not only cause currents of hot air towards the upper part of the room, but would probably make the room uncomfortable, and so lead to the opening of a door, etc.

(3) **Winds** are of great value in flushing rooms with fresh air. This ought to be done as often as possible, by throwing windows widely open; without, however, taking the place of constant ventilation in the intervals. It is especially valuable in getting rid of organic matters which are unaffected by diffusion.

The chief objections to winds as ventilating agents are that—first, the air may be stagnant, a condition which is rare in this country; and second, the movement of winds is uncertain and difficult to regulate. Thus, when the velocity is five or six feet per second, unless the air is warm, it becomes uncomfortable, and is consequently excluded.

The wind will pass through wood, and even brick and stone walls. When it is allowed to pass directly through a room, as

from window to door, it produces a more powerful effect than can be produced in any other way. Thus, air moving at the rate of two miles an hour, and therefore hardly perceptible, if allowed to pass freely through a space 20 feet wide, changes the air of the space 528 times in one hour (Parkes).

The average rate of movement of winds in this country is seven to eight miles, or about 40,000 feet, per hour; at this rate of movement, the amount and rapidity of purification would be much greater.

Winds act as a ventilating agent in two ways—**directly by perflation**, driving impure air before them, or freely mixing with it; and **indirectly by aspiration**, drawing the impure air along with them. In the last case, the wind causes a partial vacuum on each side of its path, towards which all the air in its vicinity flows. Thus, the wind blowing over the top of a chimney causes a current at right angles to itself up the chimney. In a spray-producing apparatus we have a common instance of the same principle, the current of air or steam along the horizontal tube causing the fluid to rise in the vertical tube till it is scattered in spray. In Sylvester's plan of ventilation, both these forces are used *(see page 192)*.

4. **Certain Constituents of the Atmosphere** have an important purifying effect. Of these oxygen is by far the most important. By its means organic impurities become oxidised, and thus rendered harmless. It is probable that much of this oxidation is effected by means of ozone—a peculiarly active and concentrated form of oxygen. A large part of this ozone is probably produced during thunder-storms and similar electrical disturbances of the atmosphere. The ammonia and organic impurities in air become changed into nitrites and nitrates—chiefly of ammonium—and then being washed down by rain, form an important part of the food of plants.

5. **Chemical Measures** are occasionally used for the purification of the atmosphere, and it will be convenient to enumerate them here, although they are chiefly artificial appliances. The chemical

action of ozone has been already mentioned. Many of the disinfectants in common use act by oxidising noxious matters. Thus chlorine attacks and combines with the hydrogen of any water present, and the nascent and active oxygen liberated, oxidises organic matter. Sulphurous acid, on the other hand, acts by deoxidising.

The chief disinfectants and deodorants used for the atmosphere are as follows:—among *solids*, charcoal, quicklime, dried earth, carbolic powders, and a mixture of lime and coal-tar; among *liquids*, Condy's fluid, carbolic acid, solution of chloride of zinc, terebene, sanitas, etc.; among *gaseous* disinfectants, ozone, chlorine, nitrous acid, sulphurous acid, the vapours of vinegar or carbolic acid, etc.

CHAPTER XIX.

GENERAL PRINCIPLES OF VENTILATION.

The Standard of Purity of Air.—Amount of Air Required.—Estimation by Experience, and from Physiological Data.—Cubic Space required.—Relation of this to Ventilation.—Fallacies in connection with Cubic Space.—Rules respecting Ventilation.—Inlet and Outlet.—Result of Division of Current of Air.

The Amount of Air Required.—Ventilation is chiefly concerned with the removal of the products of respiration, just as sewage is chiefly concerned with the removal of the solid and liquid excreta.

In a less degree it is required for removing the impurities produced by the burning of gas, candles, and lamps. The main problem however is the removal of the respiratory products.

The amount of carbonic acid in air is fairly proportional to that of the other respiratory products. It may therefore be taken as a measure of the impurity of the air.

The **Standard of purity** is somewhat difficult to fix. The external air ought only to contain 4 parts of carbonic acid in 10,000 parts; but it is almost impossible to maintain this degree of purity in

inhabited rooms. The experiments made by Drs. Parkes and de Chaumont shows that when the carbonic acid is ·06 per cent., or in the proportion of 6 parts in 10,000 of air, the air begins to be perceptibly stuffy ; this may therefore be taken as the limit of impurity. Pettenkofer has adopted the limit of ·07 per cent.

The problem then is to discover the amount of pure external air (containing ·04 per cent. of carbonic acid) that will be required to pass hourly through a room, for every person in that room, in order to keep the carbonic acid at the ratio of ·06 per cent.

This may be ascertained by actual observation of the air of rooms in which a given number of persons are placed; or by calculations from physiological data.

As *the result of numerous experiments* on the atmosphere of prisons, barracks, etc., where the amount of fresh air supplied per hour is exactly known, it is found that in order to keep the carbonic acid at ·06 per cent., 3,000 cubic feet of pure air are required per head per hour; 2,000 cubic feet keep the carbonic acid at ·07 per cent.; 1,500 cubic feet at ·08 per cent., and 1,200 cubic feet at ·09 per cent.

For the removal of the products of combustion of gas, an additional supply of air is required. A common gas-burner consumes nearly 3 cubic feet of gas per hour, and produces 6 cubic feet of carbonic acid. Thus, 120,000 cubic feet of air must be introduced into a room, during an evening of about four hours, to maintain the carbonic acid from this source at the proper amount, assuming that it does not escape in the meantime.

Where a number of sick persons are collected, as in hospitals and workhouses, a much freer supply of air is required. Much depends, however, on the cleanliness of the wards, and on whether the ventilation is constant in character. In St. Thomas's Hospital, the space allotted to each ordinary patient is 1,800 cubic feet, and to each patient in the fever wards 2,500 cubic feet. Thus, by changing the air of the wards twice in the hour, an abundant supply of fresh air is ensured. The mortality after operations,

and in all fevers, is much diminished by a free supply of air; and, as a rule, fever cases are better treated in temporary buildings, in which every part is freely exposed to air.

Soldiers are allowed 600 cubic feet of space per head in their sleeping rooms, which involves a change of the air five times per hour, in order that the carbonic acid may be maintained at ·06 per cent. The limit of overcrowding for lodging-houses is officially fixed at 300 cubic feet, but this is much too small.

The amount of pure air required in order to keep the carbonic acid in a room at ·06 per cent., may also be ascertained from *physiological data.*

It is found that the smallest amount of food capable of maintaining life for a day, contains 18 to 19 grains of carbon for each pound weight of the body. This, when oxidised, is equivalent to 150 cubic inches of carbonic acid; so that a man of 126 pounds (9 stones) weight produces daily 11 cubic feet of carbonic acid. This is the amount during absolute rest. We must allow one-half more to obtain a fair average, which gives 225 cubic inches per pound weight of body, or a total of 16 to 17 cubic feet for 9-stone weight (De Chaumont). The accuracy of this estimate has been confirmed by Pettenkofer, who found that, with gentle exertion during the day and rest at night, the amount of carbonic acid given off was 232 cubic inches per pound—that is, about 17 cubic feet per day for a weight of 9 stone, or $\frac{7}{10}$ of a cubic foot every hour. Assuming these figures to be correct, as each person expires ·7 cubic foot of carbonic acid per hour—*i.e.*, $3\frac{1}{2} \times \cdot 2$ cubic feet—and the proportion must not be increased beyond ·6 per 1,000 or ·2 per 1,000 more than it is in the external air, it follows that the expired air must be diluted with $3\frac{1}{2} \times 1{,}000$ or 3,500 cubic feet of pure air per hour.

Relation of Air Required to Cubic Space of Room.—If we accept 3,000 cubic feet of air as the amount required per head per hour, it is evident that this may be furnished by having a large room with comparatively little circulation of air, or having a small room with

frequent interchanges. Thus, supposing the cubic space allowed to each individual is 1,000 cubic feet—that is, 10 feet in every direction—the atmosphere will require changing three times per hour.

Now, it is found that when a current of air, at the temperature of 55°–60° Fahr., is moving at the rate of less than one mile per hour, it is not perceptible—that is, produces no draught. The rate of a breeze, which is just perceptible, is 18 inches per second, or one mile per hour. As draughts are objectionable, ventilation, in the best sense of the word, means the supplying of abundant fresh air at a rate of less than one mile per hour. Air moving at the rate of 2½ miles per hour, or 3½ feet per second, is perceived as a slight draught by all, at the average temperature of our climate (about 50° Fahr.)

Where natural ventilation is employed (*see next chapter*), the difficulties of thoroughly ventilating a small space, without draught, are very great. Thus, suppose a room of 500 cubic feet dimensions to be occupied by a man, who would require 3,000 cubic feet of air per hour. If the inlet opening is 12 square inches, the rate of movement would be 10 feet per second, or nearly 7 miles per hour; if twice this size, the rate of movement would be 5 feet per second. In either case, a decided draught would be perceived. But if the room were twice this size, the individual would be further away from the ventilating opening, and the current of air would be less felt and more thoroughly broken up.

In barracks, where 600 cubic feet are allowed per head, a change of air five times is required to supply 3,000 cubic feet of air per hour; but this makes the rooms cold and draughty (Parkes). A change of air three or four times in an hour is all that can be borne under ordinary conditions in this country, and this necessitates a supply of 1,000 or 750 cubic feet of space respectively for each individual. And a change of this frequency is commonly not effected; the ventilating apparatus may fail temporarily, or may be wilfully stopped up, or there may be no means of ventilation; it is essential therefore to have as large a cubic space as possible. However, it

must be distinctly understood that if one had to choose between a room of small dimensions, but well ventilated and without draught, on the one hand, and a large room with no means of ventilation on the other, the former would be preferable.

(1) In relation to the cubic space of a room, it is most important to note that *a lofty ceiling does not compensate for deficiencies in floor-space.* One hears, "lofty" and "airy" rooms spoken of as though the two terms were necessarily synonymous. This is by no means the case. The impurities produced by respiration tend to accumulate about the persons who have evolved them, although it is true that in rooms heated by gas-light, a large amount of hot and impure air collects near the ceiling. The necessity of an abundant floor-space, is shewn by the fact that a space enclosed by four high walls and without a roof, would, if crowded speedily become offensive; and persons in a crowd in the open air have been known to be suffocated. Twelve feet is quite high enough for ordinary rooms, though of course there is no objection to a greater height, if it is remembered that in reckoning the *practical* cubic dimensions of a room, the height should only be reckoned as twelve feet. Supposing 500 cubic feet is the amount allowed per individual, then the floor-space should be forty-two square feet, which would be furnished by a room about 8½ feet long and 5½ feet wide. In barracks, soldiers are allowed fifty square feet of floor-space. In school-rooms the Privy Council require that eighty cubic feet should be allowed for each child in average attendance, and at least fifteen square feet of floor-space.

(2) Another error commonly entertained is that a large room compensates for a deficient circulation of air. *The cubic space of a room is really of less importance than the capacity for frequent interchanges of air.* Even the largest enclosed space can only supply air for a limited period, after which the same amount of fresh air must be supplied, whether the space be small or large. Thus, supposing that as large a space as 10,000 cubic feet per head were allowed, the limit of purity would be reached in three hours, and after that

time an hourly supply of 3,000 cubic feet of air would be just as necessary as if the space were only 200 cubic feet. Or if 2,500 cubic feet of space be allowed per head, this would be rendered impure in less than one hour, and then a constant interchange at the rate of 3,000 cubic feet per hour would be necessary.

(3) A third fact commonly overlooked, is that the *furniture in a room* must be deducted from the breathing space, as the amount of air is diminished by the space occupied by the furniture. About 10 cubic feet ought to be allowed for each bed, and 3 to 5 cubic feet for each individual in a room; projecting surfaces must be allowed for by subtraction, and recesses by addition. The deductions to be made for furniture are not of any great consequence, if there is a free interchange of air; as the cubic space is of much less importance than free ventilation.

General Rules respecting Ventilation.—The two great objects in ventilating being to remove all impurities from the air, and to avoid draughts, it is important that—

1. *The entering air should be, if possible, of a temperature of about 60° Fahr.* Whenever the temperature of a room differs from the external temperature by 10° Fahr., a draught is certain to ensue. It is impossible at all times to ensure the incoming air being of the temperature of 60°, without some artificial means of warming it.

2. *The entering air should be pure.* When a room is hotter than the passages and kitchens, air from the latter, whatever may be its character, is drawn into the room. Similarly the ground-air under the kitchen-floor may be drawn into the house, and the air from dust-bins, when no other means of ventilation are provided; and this is often followed by dire results.

3. *No draught or current should be perceptible* from the in-coming air, except when it is wished to flush the room with air, by opening the windows wide. It is a common complaint that a room is draughty, and to remedy this keyholes are stopped up, and mats are placed at the bottom of the door, etc. The draught can

often be remedied by increasing the size and number of the openings through which air is admitted, so that the current of air is not so concentrated and rapid. Where this does not remedy it, the in-coming air should be warmed.

4. *The entry of air should be constant not intermittent.* The occasional opening of a window or door will not compensate for the lack of a constant interchange of air, although it forms a very valuable adjunct, especially in the removal of certain organic matters which do not follow the law of diffusion.

5. *An exit should be provided for impure air*, as well as an entrance for pure air. The chimney furnishes this in most living-rooms, and diminishes the necessity for some other means of exit.

Dr. de Chaumont has shown that if the openings in a room for entrance and exit are properly regulated, a rate of 5 feet per second (about 3½ miles per hour) will provide sufficient air without any unpleasant draught in a room. For instance, if the opening measure 1 square foot, then a rate of 5 feet per second would give 5 cubic feet of air per second, that is, 18,000 cubic feet per hour. But as only 3,000 cubic feet are required, it follows that an opening one-sixth this size, *i.e.*, 24 square inches, is sufficient for each individual. Reckoning the same amount for means of exit, 48 square inches is the size of the ventilating orifices required by each individual.

6. *A number of small divided openings are not collectively equal in ventilating power to one large one having the same area.* Thus, when a ventilating orifice is divided into four parts, which have the same collective area as the original orifice, it is found that only half as much air passes through these as through the original orifice. In order to obtain as much air, therefore, each opening must be equal in size to half the original opening. When the size of the apertures is still further diminished, the diminution in the current through each one is still greater.

7. It will be useful in concluding this chapter, to re-state the most important requirements of perfect ventilation.

1st. The maximum impurity of air vitiated by respiration should not exceed 6 parts carbonic acid per 10,000 volumes.

2nd. To ensure the maintenance of this standard, 3,000 cubic feet of pure air must be supplied per head per hour.

3rd. In order to supply this amount of pure air, with ordinary means of ventilation, 1,000 cubic feet at least must be allowed per head in buildings always occupied.*

CHAPTER XX.

METHODS OF VENTILATION.

Flushing Rooms.—Lying Fallow.—Inlets and Outlets.—Natural Ventilation by the Window, Chimney, Ceiling, Wall, Door, and Floor.—Artificial Ventilation.—Aspiration and Propulsion.—Relative Value of Natural and Artificial Ventilation.—Obstructions to Ventilation.—Ventilation of Upper Stories.

In most houses no means of ventilation are provided, the supply of fresh air being left to circumstances or never thought of. Fortunately, the wood-work of houses is, as a rule, not well put together, and the walls are somewhat porous; in these ways, a certain amount of air manages to get into the room. In order to ensure perfect ventilation, however, ventilators should be provided for a house at the time it is built, with as much care and forethought as is incurred in the laying on of a water-supply.

Whatever the system of ventilation adopted, it is always wise to *flush rooms frequently with fresh air*. This is best effected by throwing the windows wide open whenever a room is left unoccupied. In this way a much more thorough and complete purification is effected than by any other means. This is especially important in the case of bed-rooms, in which organic impurities are most prone to accumulate.

Not only should rooms be ventilated, but likewise *the furniture* they contain. This, again, is most important for bed-rooms. Beds

* Further particulars as to ventilation, and the problems connected therewith, will be found at page 417.

should not be "made" till some time after using; and in the interval, should be freely exposed to the air. The same applies to night apparel. It is a good plan also where feasible, to distribute the day apparel on different chairs in a dressing-room, in order that it may be freely exposed to the air during the night.

It is well to allow *rooms to lie fallow* at intervals. Organic matter accumulates about a room, and devitalises any air which enters. If the room is vacated, and flushed with air for a continuous period, it becomes sweeter and purer. The importance of this is now well recognised in the case of hospital wards, and is frequently acted on

An Inlet and Outlet for air should both be provided. According to some an inlet only is required, while others would only provide an outlet; but a perfect system of ventilation requires both. *The relative size* of inlets and outlets has been the subject of much discussion. As heated air expands, the outlets should theoretically be larger than the inlets; but as the average difference of temperature is only 10—15 Fahr., the expansion is only slight, and may be practically neglected.

Inlets should bring air from a pure source. They should not be large and single, but rather small and numerous, so that the air may be equally distributed. Externally, inlets should be protected from the wind; and the shorter the inlet tubes the better, as thus a current is ensured, and they can be easily cleaned. The position of inlets should not be too near the outlets, otherwise the fresh air may escape immediately. The best position for inlets is at the floor, but this necessitates warming the entering air, as otherwise it would be intolerable, except in summer time. If the air cannot be warmed, it should be admitted from seven to ten feet above the floor, and directed upwards.

According to Parkes, it is desirable that each individual inlet should not be larger than 48 to 60 square inches in area—that is enough for two men or a little more; and that each outlet should not be larger than one square foot, or enough for six men.

Outlets, under ordinary circumstances, are best placed near the ceiling. They should be enclosed as far as possible within walls, so as to prevent the out-going air being cooled; and should have smooth walls, reducing friction to a minimum. Where artificial warmth increases the temperature of the air, the discharge of outlets is much more certain and constant. The chimney with an open fire forms one of the best outlets. Gas, again, may be made to heat an outlet tube, which carries off the products of combustion.

Two forms of ventilation are usually described—natural and artificial. The former term is used to describe any plan not requiring an apparatus which involves trouble or expense in its working, while the latter implies the use of some special and commonly expensive apparatus. It is obvious, however, that there is no sharp line of demarcation between the two. A lighted fire is strictly an artificial plan of ventilation, involving some expense, but inasmuch as no apparatus intended for ventilating purposes is required, it is hardly a means of artificial ventilation.

Natural Ventilation.—All the parts of a room may serve as means of natural ventilation. The most important of these are, however, the window and the chimney.

The Window is perhaps the most important agent in purifying a room—both the light and air it admits being essential for health. Unfortunately, the window can be least used in winter, when the need for it to be open for purifying purposes is perhaps greatest. The window is invaluable (1) **for flushing the room** with fresh air at intervals. Where possible, opposite windows should be opened, or window and door.

(2) **The Upper Segment** of a window may be made to work on a hinge, and turned so that the current of air may be upwards. Where this plan is adopted, it is wise to have triangular pieces of glass at the two sides, preventing the cold air falling immediately.

(3) **A Block of Wood**, two or three inches wide, may be inserted at the bottom of the window sash at A (*Fig. 15*), and then the window pulled down on this. The consequence is that air is admitted

between the two sashes at B, its current being necessarily directed upwards (*Fig. 15*). This plan answers admirably in admitting pure air; but it possesses a disadvantage common to all the plans in which external air much colder than the internal is admitted into a room. The current of cold air passes upwards for some distance, and then falls down with an increasing rapidity on the heads of those occupying the room; thus producing an uncomfortable draught.

FIG. 15.
WINDOW VENTILATION.

(4) The top sash of the window may be opened, and some **zinc gauze** fastened across the open part. This is practically the same as the last arrangement, with the additional advantage of the admission of some air through the zinc. It must be remembered that the admission of air through a number of minute apertures like this is much smaller than through the same area in one continuous piece.

(5) In **Louvre Ventilators**, a number of parallel pieces of glass, each of which is directed upwards, are substituted for a pane of glass. They may be fixed or made movable, as in Moore's ventilator. The incoming current of air may be directed upwards, in the case of an open window, by arranging Venetian blinds with the laths inclined upwards.

(6) In windows that will not open, **Cooper's Ventilators** are useful. Each of these consists of a circular disc of glass, having five oval apertures in it, which works on a pivot through its centre, close in front of one of the panes of a window, which has five similar holes pierced in it. Consequently, when the disc is turned, so that its holes are opposite those of the window, fresh air is admitted.

The Chimney forms the best means of escape of foul air, and no room ought to be built without a chimney. In bedrooms they form a most important means of ventilation, when they are not boarded up. If there is no fire, chimneys may occasionally provide an inlet of air; but as a rule the current in them is upwards, owing to the aspirating action of winds at the

top of the chimney. The downfall of air from a chimney chiefly occurs when there is an insufficient inlet for pure air. This is the explanation of **smoky chimneys** in nine cases out of ten; then the cure is easy by laying on a pipe from the outside of the house to the hearth. When the smoky chimney is due to the contiguity of higher buildings, the chimney must be raised, or a cowl placed over it. Cowls may be either lobster-backed, turning with the wind, or fixed, the latter being preferable.

(1) The action of the chimney in carrying impure air away from the room may be considerably increased by **narrowing the two ends,** so as to produce a more rapid current at the entrance and exit of air.

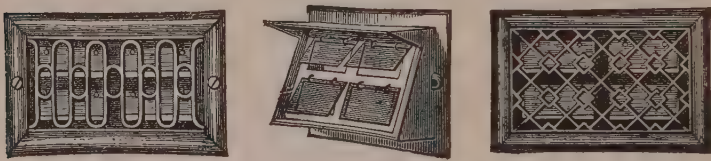
(2) The heat of the chimney may be utilised by having a **separate smaller flue** alongside it, which communicates with the rooms on each floor. The air in this being heated aspirates the air from each room in succession.

Openings may be made into the chimney-flue at a higher point than the fire-place. These are very valuable for carrying off the heated and impure air resulting from the combustion of gas, as well as for carrying off the respiratory products, which, in their warmed condition, tend to rise towards the ceiling.

(3) **Dr. Neil Arnott** first devised a valve for this purpose. An opening being made through the upper part of the wall into the chimney, an iron box was inserted, in which was placed a light metal valve capable of swinging towards the chimney flue, but not towards the room. The objections to this apparatus are that it is apt to make irregular clicking noises, and to admit blacks from the chimney when out of order.

(3) In **Boyle's Valve** these objections are partially obviated. It consists of an iron frame, across which lie iron rods; and from these are suspended thin talc plates, only capable of moving in the direction of the chimney (*Fig. 16*). Even this apparatus is rather noisy when there is a strong wind.

Neither of these plans answers so well as a second flue along side the chimney flue, communicating with each room near its



VIEW FROM ROOM. VIEW FROM CHIMNEY. VIFW FROM ROOM.

FIG. 16.—BOYLE'S MICA FLAP VENTILATOR.

ceiling; but the latter can only be arranged for when the house is built, while the valves may be inserted at any time.

The Ceiling may be utilised for removing foul air; and thus serve to diminish the draught which is often produced by the currents of air towards the chimney, when this forms the only means of outlet.

In large rooms, (1) **a sunlight** forms an important means of ventilating. It causes considerable draught, however, from every part of the room.

(2) **Benham's Ventilating Gas Burners**, which carry away the products of combustion, are useful for the same purpose.

(3) A porous ceiling, with a grating or perforated brick in the outer wall between the ceiling of the room and the flooring of the room above, is adopted in some cases.

(4) **McKinnell's Ventilator** consists of two tubes encircling one another, the inner forming an outlet tube, because the casing of the outer tube maintains the temperature of the air in it. It is made higher than the outer tube, and is protected by a hood. The outer tube forms the inlet for fresh air. The entering air is thrown up towards the ceiling and then to the walls by a flange placed at the bottom of the inner tube. The air after traversing the room, and becoming heated, passes upwards to the inner tube. When doors and windows are open, both tubes become outlets;

if there is a fire in the room, they may both become inlets; but this may be prevented by closing the outlet tube.

(5) One of the best outlet ventilators is furnished by an aperture in the centre of the ceiling, opening into **an air-tight zinc chamber** between the ceiling and the floor of the room above, from which a zinc pipe runs straight into the chimney, the opening into the latter being guarded by one of the chimney valves already named. This apparatus is difficult to fix in an occupied house; a preferable plan would in that case be to insert one of Boyle's valves in the chimney flue.

(6) **Boyle's Air-pump Ventilator**, shewn in *Fig. 17*, consists of four segments acting independently of each other. In *Fig. 18*

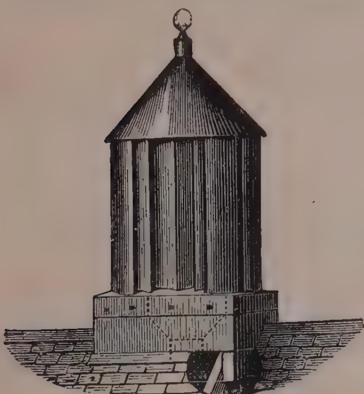


FIG. 17.
BOYLE'S AIR PUMP VENTILATOR.

FIG. 18.
SECTION OF THE SAME.

these parts are shewn in section. 1 in that figure represents a curved guard which serves to concentrate the current and prevent the wind blowing through the slits opposite. At 2 is a curved plate with the concavity outwards which prevents any down draught, and takes the pressure off the vertical slits communicating with the interior. The external air impinging on the diaphragm 3, is reflected on to the plate 4, thus creating an induced

current, and drawing the air from the vertical chamber 5, expelling it at the opposite opening. The ventilator is connected by means of a shaft with the apartment to be ventilated, and the impure air rushes up from the latter to fill the partial vacuum thus produced. At 6 are seen the partitions separating the chambers, which prevent external air being drawn through the slits on which the wind is not directly acting.

In the above plans of ventilation, the ceiling serves almost entirely as an outlet for impure air. In the following plan, it is used as an inlet for pure air.

(7) In **Sylvester's Method of Ventilation**, the perflating force of the wind is employed to produce an abundant entry of fresh air. A cowl is placed, always turned towards the wind; the air received is conducted to the basement, where it is warmed by a stove or hot-water pipes, and then passed through tubes into the upper rooms. From these it is carried by tubes above the roof, these tubes being covered with cowls turning from the wind, so that in this way the aspirating power of the wind is likewise used.

Ships are constantly ventilated in a somewhat similar manner. The tube to which a windward cowl is attached above, ought to be bent at right angles, so as to lessen the velocity of the entering air and prevent draughts. By covering other air-shafts with movable cowls, turned from the wind, the aspirating action of the wind is brought into action to aid the escape of foul air.

The Walls of a room, unless covered with an impervious material, are constantly traversed by gentle currents of air, which play an important part in the ventilation of rooms. Special apertures may be made to furnish a freer supply, and these may be in various forms.

(1) A **Simple Grating**, composed of perforated zinc, is often used, but an iron grating is better. The holes in the zinc get blocked with dirt, and do not allow a large amount of air to enter.

(2) A **Louvred Opening** may be arranged, after the same style

as those used for windows. This should be made so that it can be closed or opened at will.

(3) **Sheringham's Valve** is perhaps the most convenient means of ventilating through the wall. An opening in the external wall is made by a ventilating brick or grating; into the wall is fixed an iron box, which has in front of it an iron or wood valve hinged along its lower edge, so that it can open towards the room. On the sides of the valve cheeks are attached, which fit into the box when the valve is shut. A heavy piece of iron pressing against the valve from within the box, tends to keep it constantly open. By means of a string and pulley, the valve can be opened or closed at will, or fixed in any intermediate position.

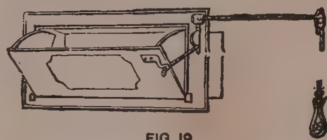


FIG. 19.
HAYWARD'S SHERINGHAM VENTILATOR.

In a very large room, it is better to have several medium sized valves, than a few larger ones, the air being thus more completely diffused. If there are two valves, they should not be opposite one another, as the air may then simply pass from one to the other, without becoming diffused through the room. If there is only one valve, it may occasionally serve as an outlet when the wind is to leeward. By means of this form of valve, the air is projected upwards in a diverging current towards the ceiling, where it mixes with the hot and impure air, and then makes its way to various parts of the room, and to the outlet, most commonly the chimney. The valve should be placed above the level of one's head, but not too near the ceiling; as in the latter case, the current of air is driven hard against the ceiling, and falls thence with considerable force towards the floor. A combination of Sheringham's inlet and Boyle's mica outlet in an ordinary living-room ensures efficient ventilation.

(4) **Ellison's Inlet** consists of a brick pierced with conical holes, the apex of the cone being towards the external air. By this means any great draught is avoided, and the air is distributed over

a considerable area. In order that this may prove an efficient means of ventilation, a considerable number of bricks are required. The same precautions are required as in the case of the inlets and outlets already mentioned.

The **Floor** of a room is always the source of considerable currents of air, even when well carpeted. Air mounts up through the crevices of the wood-work, being aspirated into the room when its temperature is higher than that of the rooms below. In the case of rooms on the ground-floor, air is often drawn from the subjacent soil, or through dust-bins, etc.

Theoretically, in all measures of ventilation, the floor would be the best point for the entry of cold air. This, however, is intolerable when the incoming air is cold, and the floor must therefore be abandoned as a means of ventilation, apart from heating apparatus.

The floor may be used as a means of entry of fresh air in a modified manner, by directing the air entering at the floor-level for some distance up a tube at the side of the wall. This apparatus is known as **Tobin's tube.** It consists of a rectangular or cylindrical tube from 4 to 6 feet high, which communicates at its lowest point with the external air by means of a perforated brick or grating. The air enters the room in an upward direction, and is consequently sent towards the ceiling, where it becomes mixed with warmer air, before diffusing itself throughout the room. But when the incoming air is very cold, it may fall more rapidly, causing cold draughts on the heads of those in the room. For this reason the tube is usually provided with a lid, which may be shut or opened to a varying extent.

As the air enters directly from outside the house, it often carries with it particles of dirt, soot, etc. This may be remedied in various ways. (1) A pan containing *a shallow layer of water* may be placed at the lowest part of the tube. This, for the time, effectually stops the dust, and renders the incoming air moist: but it soon evaporates, and then is commonly not renewed. (2) *Cotton-*

wool may be placed at the point of entry of the tube into the room. This acts very well for its immediate object, but the entry of air, with a plug of cotton-wool inserted, is greatly diminished. It is very useful however in cold weather, or when fogs occur. (3) A better plan is to have a *gauze funnel* inserted in the tube, or a sheet of gauze arranged diagonally across the tube from its highest to its lowest point. These do not diminish the current of air so much as cotton-wool, though still appreciably; but they require to be occasionally cleared from the collected dust.

Artificial Ventilation.—Artificial ventilation may include two important and very different measures. In one of them currents of air and an exchange of pure for impure air are effected by means of various forms of heating apparatus. In the other mechanical measures are used for the same purpose,—the air being either driven out of the room or drawn out of it. In this chapter we shall consider only the **mechanical means of artificial ventilation**. There are two kinds, the first being known as ventilation by aspiration, or the *vacuum* system; and the second as ventilation by propulsion, or the *plenum* system.

In **Ventilation by Aspiration** the foul air is drawn out of the room by machinery, its place being supplied by fresh air, which may be warmed before entry or not. This plan and the next have been employed chiefly in connection with large buildings, such as hospitals, etc., and in mines.

The extraction of foul air may be effected by—(1) *a steam-jet*, which is allowed to pass into a chimney, and sets in motion a body of air more than 200 times its own bulk. Tubes from each room of the building are connected with this chimney, and the strong upward current extracts the air from them. This plan is useful in factories, where there is a superfluous supply of steam.

(2) *A fan or screw* may also be used. The vanes of the fan, when it is caused to revolve by some stationary machinery, produce a powerful current of air, which can be regulated according to requirements. As in the last plan, the aspirating influence of

the fan may be exerted over a system of rooms, by means of connecting tubes. Placing an Archimedean screw in a chimney, to be turned by the wind, has been proposed, but is of little use.

In **Ventilation by Propulsion** a fan is used as in the last plan, the air being propelled along conduits leading from it, into the room to be ventilated. The size of the conduits being known, the amount of air to be discharged can be regulated by timing the rapidity of the revolutions of the fan.

This plan is suitable for crowded places, where a large amount of air is required in a short time. It is also used in the new ironclads, large fans being driven by special machines. The air to be admitted may be warmed by connecting the conduits with some form of heating apparatus.

Besides the fan, various forms of bellows, and a gasometer pump, have been used for the same purpose.

The punkah used in India is a more imperfect apparatus of the same kind. By its means a quantity of air is forced out of the room, and fresh air rushes in from all sides to supply its place. The cooling effect of the punkah is greatly increased by moistening it.

The great advantage of the plan of propulsion, is its certainty. By it the temperature, moisture, and freedom from suspended matters of the incoming air can be exactly regulated and controlled. Its chief disadvantages are that (1) it is a very costly method; (2) the apparatus is liable to break down; and (3) the distribution of the fresh air over different rooms is rather difficult. When combined, as is done in the Houses of Parliament, with the use of a flue for the extraction of foul air, this plan seems to answer admirably.

The Relative Value of Artificial and Natural Ventilation is not very difficult to adjudge. When possible, there can be no doubt that natural ventilation is by far the best plan. But it is impossible to say that in all circumstances, one is better than the other. When the external air is very cold, it cannot be admitted directly without the production of draughts. Then, some means

of heating the incoming air must be adopted. (Chapter XXI.) When again, the air is warm and comparatively stagnant, as in the hottest part of summer, the ventilation is probably more imperfect with windows widely open, than it is sometimes in mid-winter with curtains drawn and doors shut. In these circumstances some apparatus like the punkah would be useful; or at least, both door and window should be open in order to ensure some slight draught through the room. This applies still more to tropical climates.

In certain large buildings again, where there is a large number of rooms, some artificial means of ventilation is required.

The chief objections against artificial ventilation are those given under the head of ventilation by propulsion. In addition may be named the danger of the long tubes through which air is carried becoming leaky, and so contaminations getting into them. The long tubes also produce great friction, and thereby diminish the current of incoming air.

Obstructions to Ventilation.—1. *Any irregularity in shape or roughness* of the opening will retard the movement of air, by increasing the friction; circular and semicircular orifices cause least friction; a square opening is the next best.

2. The opening may become *clogged with dust and soot.* All ventilators require occasional attention and cleansing. The dust often contains a large proportion of organic matter, and this tends to devitalise the entering air.

3. The insertion of a *grating or of gauze* into the opening, greatly retards the current of air. A number of small openings—the sum of whose area is equal to that of a large opening—do not furnish as much air as the latter. Thus, if an opening, ten square inches in size, is replaced by five openings of two square inches each, the amount of air supplied by each of these is not *one-fifth* of the original amount, but only about *one-sixteenth.* Hence, 32 square inches, so divided, are only equivalent to ten square inches in a single opening.

4. The *ventilating tube* may be *too long* in proportion to its width, or it may be *bent or twisted.* In all these circumstances friction is increased, and the current of fresh air correspondingly diminished. When a ventilating tube is bent at right angles, half the air-current is lost; if there is a second right-angled bend, only one-fourth of the original current is obtainable.

5. Ventilation is much more difficult in *upper rooms of large houses*, and in *single-storied houses*, than in the lower stories of large houses. The cold external air by the attraction of gravity presses downwards to the lowest point, and pushes up the warmer air. The rate at which it presses downwards depends partly on its temperature, and partly on the height through which it has to fall; in the latter respect following the usual law with regard to falling bodies, that the space traversed will equal half the force of gravity (= 32) multiplied by the square of the time. Thus it will be 16 feet in the 1st second, 64 in the 2nd, 144 in the 3rd, etc. The height from which the cold air has to descend may be measured from the floor of the room to be ventilated to the point of issue of the foul air, which is commonly the top of the chimney. If calculations are made on this basis, it will be evident that the air entering a room on the ground floor will have a much greater velocity imparted to it than that entering a room on the highest storey; and that, consequently, although 24 inches of ventilating inlet, and an equal amount of outlet, suffice in the former for each individual case, it probably will not keep the air pure in the latter case. A few inches must be added for each storey as we ascend, and a cottage or single-floored dwelling must be treated as a top-storey. (De Chaumont).

CHAPTER XXI.

VENTILATION BY THE INTRODUCTION OF WARMED AIR.

The Chimney as an Outlet and Inlet for Air.—Galton's and other Stoves.—The Ventilation of Mines, Men-of-War, etc.—Ventilation by Hot-Water Pipes.—Ventilation by Gas.—George's Calorigen.—Objections to Ventilation by Warming Apparatus.

Ventilation by the Burning of Coal.—In winter and at any time of the year when the out-door temperature is below 50° Fahr., the warming and ventilation of a room are necessarily combined. If air is admitted unwarmed it is certain to produce draughts, unless it is directed upwards by Tobin's tubes and mixed thoroughly with the hot air near the ceiling. In the comparatively small rooms of dwelling-houses, some such contrivance may suffice; but in any larger building, in order to ensure ventilation, it is necessary to warm the incoming air.

The Open Fire-place forms the most common means of ventilating by heat. It has been already considered in the previous chapter, but we must now consider the mechanism by which it produces a constant circulation of the air in a room. The ascent of warm air up the chimney, causes cold air to rush along the floor to the fire-place from all parts of the room, especially the door. Part of the air thus approaching the fire is carried up the chimney with the smoke, while the remainder, after having been warmed, flows upwards towards the ceiling near the chimney-breast. It passes along the ceiling, and cooling in its progress towards the opposite wall, descends, and is again drawn towards the fire-place. Thus there is a continuous circulation of the air in a room.

In the experiments of the Barrack Commissioners (1861), it was found that the amount of air passing up the chimney while a fire was lit, ranged from 5,300 to 16,000 cubic feet per hour, the

mean of 25 experiments being 9,904 cubic feet. We may conclude, then, that with an ordinary grate, a chimney provides outlet for impure air sufficient for four or five persons. Its lack of economy as a heat-producer will be considered later. Its efficiency as a ventilator within the above limits is evident.

When a fire is burning in the grate, all other openings in the room, except openings into the chimney, serve as inlets. If the room is insufficiently supplied with openings, a double current may be established in the chimney, with the result that occasional down-puffs of smoke occur.

As a rule the chimney serves only as an outlet for impure air. It may by appropriate means be made to serve as an *inlet for pure and warmed air*, the heat which would otherwise escape up the chimney being utilised for this purpose. The **stove** contrived by **Captain D. Galton** is one of the best for this purpose. At the back of this stove is an air-chamber, communicating with the external air, and in which the fresh air is heated before it enters the room. On the back of the stove broad iron flanges are cast, in order to present as large a heating surface as possible. They project backwards into the air chamber; and their heating surface is aided by the iron smoke-flue, which passes through the air-chamber. The warmed fresh air enters the room by a louvred opening above the mantel-piece, or by an opening in each side of the chimney-breast. The grate itself is constructed so to give out as much heat as possible, and the smoke is much more completely burnt than with an ordinary grate.

Boyle's and Shorland's grates are similar in principle to Galton's. In **Boyle's Ventilating Grate** the heated air enters the room through small openings extending along the top of the grate.

In **Shorland's Manchester Grate** the warmed air enters the room through the shelf of the chimney-piece, and can be carried by means of suitable flues to warm the bedrooms, etc.

The Ventilation of Mines is effected by lighting a fire at the bottom of a shaft. The air for the combustion comes down

another shaft (the intake shaft), or down another half of the same shaft separated by a partition. The consequence is that a constant up and down current of air is produced. The air from the intake shaft is made to traverse the galleries of the mine, its course being directed by partitions, before it is allowed to reach the fire and so be carried up out of the mine. From 1,000 to 2,000 cubic feet of fresh air are supplied per head per hour in good mines; in fire-damp mines as much as 6,000 cubic feet. As showing how skilfully the air is guided in its course through the galleries of a mine, it may be mentioned that in some mines the air makes a circuit of from thirty to forty miles before reaching the shaft whence it leaves the mine.

The Ventilation of Large Buildings has been effected in a similar way. A chimney has a fire lit at its lowest part, and into this shaft, close to the fire, a number of tubes run from the different rooms. The Houses of Parliament were ventilated for some years by this plan. The workmanship must be very exact, or else air gets into the ventilating shaft otherwise than from the tubes.

Some **men-of-war** have been ventilated in a like manner. The funnel and upper part of the boiler are enclosed in an iron casing, a space of three or four feet being left between the two. When the fires are lit a strong upward current is produced in this space, and to supply the partial vacuum produced, air is drawn through all the hatchways towards the furnace doors. This plan may be applied to ventilate not only the furnace-rooms, but the whole ship. The same principle has also been applied in the ventilation of sewers.

In addition to, or instead of, an ordinary coal-fire, the extractive force for impure air may be obtained from HOT WATER OR STEAM PIPES. There are various plans founded on this principle.

When hot-water pipes are used for baths, etc., they may also be utilised for ventilation, in two ways:—1st. The hot-water pipe may be made to coil round the tube by which fresh air is admitted into a room, thus warming the air as it enters. 2nd. The hot-water pipe

in its course upwards may be enclosed in a shaft, which opens into the external air above. The air in this shaft being heated, the impure air may be collected and removed from the different rooms by tubes connected with it. Thus, a hot-water apparatus, when well arranged and complete, may furnish pure warm air, and carry away impure air. The ventilation by this plan is found in practice to be somewhat irregular.

The plan proposed by Drs. Drysdale and Hayward of Liverpool is similar in principle:—Fresh air is warmed by a coil of hot-water pipes in the basement, and is admitted into the staircase and landings, whence it is supplied to the different rooms by openings provided with valves. From the rooms, special outlets converge to a foul-air chamber under the roof. This is connected with a shaft leading from the kitchen-fire, the latter, therefore, acting as an extraction furnace.

Lighted Gas may be employed to produce a current for ventilating purposes, as well as a fire or hot-water.

Sunlights, and **Benham's Ventilating Gas-burners**, have already been mentioned in this connection. They are unfortunately expensive, but are extremely valuable means of ventilation. Sunlights, unless carefully managed, produce powerful centripetal currents from all quarters of the room, so much so that it is impossible to sit near any point at which air is entering.

In theatres and similar buildings the **Chandeliers** should always be made to extract the vitiated air. Where a number of chandeliers exist, they may be connected by tubes with a main shaft, and all made to contribute to the same object. According to the experiments of General Morin, the discharge of 1,000 cubic feet of air is produced by the combustion of one cubic foot of gas. As a common gas-burner will burn nearly three cubic feet of gas per hour, the value of this means of ventilation is evident.

Dr. A. Carpènter describes a useful form of ventilation and warming by gas, suitable for schools. It consists of a number of Tobin's tubes, at various parts of the room, each enclosing a set of

minute Bunsen's burners, fitted to the bottom of the tube, but capable of receiving the air for their combustion from the room. The products of combustion are conveyed directly out of doors, through a smaller tube lying inside the Tobin's tube, the smaller tube being so arranged that no deleterious gas can possibly enter the room. The Tobin's tube brings fresh air from without, which is warmed by the heat from the Bunsen's burner before it enters the room. About 100 feet of gas per day are said to be ample for a schoolroom containing 100 children.

Various forms of gas-stove are now sold, which act as ventilators as well as sources of heat. Of these, one of the best is **George's Calorigen Stove** *(Fig. 20)*. It can be obtained in various forms suitable for burning coal-gas, or coal, or oil. Within its outer case is contained a special iron tube, which communicates at its lower end with the outer air, and opens at its upper end into the room. The heat generated in the stove warms the air in the spiral tube, which accordingly ascends into the room. The ascent of warm air causes a draught from below, and the consequence is, that so long as the combustion is going on, a current of warm air continues to ascend into the room. The products of combustion are carried out of the room by the pipe F. This stove is free from most of the objections appertaining to gas-stoves; it can be fixed into an ordinary fire-place, and it keeps the temperature of a room at a uniformly warm point.

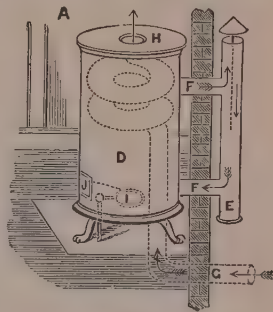


FIG. 20.
GEORGE'S CALORIGEN STOVE.

A—The interior of room.
B—Exterior of building.
C—Wall.
D—The Calorigen.
E—A cylinder.
FF—Pipes communicating with Stove and Cylinder to supply air for combustion, and to carry off the products of combustion.
G—Pipe for passage of fresh cold air to Calorigen. Can be carried above the floor or between the joists, as may be most convenient.
H—Outlet for air into the apartment after being made warm.

Objections to Ventilation by Heating Apparatus.—When

warmed air is admitted into a room, it is very apt to be *dry*, and consequently produces headache and a feeling of oppression. This can be usually avoided by having water standing in the room, so as to allow evaporation.

When the impure air is extracted by fire or hot-air shafts, various objections arise:

1. The *draught is unequal* at different times, owing to the fire not being kept at the same level.

2. Unless the building is a very compact one, the *current of air is very unequal* from the various rooms; being strong from the rooms nearest the shaft, and very slight from remote rooms.

3. When the flue is accidentally blocked, or from other causes, *smoke* or *impure gases* may occasionally re-enter the rooms from the shaft.

4. When the draught is most perfect, it is most difficult to control the places *whence air shall enter the rooms.* It may be forced out from water-closets, or even from sewers, instead of from proper sources. This objection is to a large extent overcome, by combining the extraction of foul air by heat, with some one of the previous plans for an abundant entry of moderately warmed air.

CHAPTER XXII.

THE WARMING OF HOUSES.

The Degree of Temperature Required.—The Modes of Carriage of Heat.—Different Methods of Warming Houses.—The Open Grate.—Objections and Advantages.—Open Gas Fires.—Improvements in Open Grates.—Closed Stoves.—Whole House Systems.—Hot-water Pipes.—Warming by Hot Air.—Boyle's Air Warmer.

Physiological and Physical Considerations.—The warmth of our bodies is naturally kept up by the oxidation changes

constantly going on in the system. We shall discuss in Chapter XXIII. the modes in which heat is lost by the system, and the influence of clothing in controlling the amount of this loss. Artificial warming of houses has a similar action to clothing. It diminishes the demand on the system, and so economises the amount of fuel-food required.

The degree to which this diminution of loss of heat by clothing and artificial warming of houses may be carried varies with circumstances. There can be no doubt that if food be abundant, exposure to external cold, if not too extreme, is on the whole beneficial, for vigorous people. But for old people and young children, the means of artificial warmth require to be more carefully attended to. Severe cold is for them often the harbinger of death.

The **Degree of Temperature** at which living-rooms should be kept will vary somewhat with circumstances.

For *healthy adults* any temperature between 50° and 60° Fahr., will be moderately comfortable; for *delicate children and old people* it may be 65° with advantage. It must always be remembered however that a temperature lower than this and fairly uniform, is preferable to frequent changes from a high to a low temperature.

For *sick rooms and hospitals* the temperature of 60° is usually adopted, but this is by no means always necessary. In most fevers, with the doubtful exception of scarlet fever, better results are obtained by keeping the temperature of the room as low as 50°. This has been abundantly proved in small-pox for instance; the proportion of recoveries being larger in tent hospitals than in permanent structures.

Convalescents from any acute illness bear low temperatures badly, and during this period exposure must be avoided.

The Different Kinds of Warmth.—Heat may be communicated by radiation, conduction, and convection. By **radiation of heat** is meant the process by which heat passes from a fire or other source of heat, through a vacuum, dry air or any other medium, without

heating any of the media through which it passes, but only the bodies against which it finally impinges. The solid bodies (including ourselves) which are warmed by radiant heat, by a process of conduction then warm the surrounding air.

Conduction of Heat is the passage of heat from one particle to another, whether it be of a gas or solid. It is an extremely slow process when air is concerned, and may be practically ignored.

Convection of Heat is the process by which a gas or liquid actually carries the heat in itself from one part to another. The heated particles are relatively lighter, and ascend to the higher parts of a room, while colder and heavier particles descend, and are subjected to the same process. Heat can be carried by convection only by gases and liquids. It is quite possible, therefore, to have a room filled with warm air, and yet for a person to be cold in it, if the walls, etc., are cold; while, on the other hand, he might feel comparatively warm in a room filled with cold air, owing to an open fire-place or the warm walls radiating to his body more heat than he radiates to the surrounding structures. The great advantage of radiant heat, then, is that—(1) it heats the body without heating the air; while at the same time (2) there is no possibility of impure gases being added to the air.

It has, however, considerable disadvantages. (1) It is costly, though its expense may be greatly diminished by a well-constructed fire-place. (2) It only acts on bodies near it to any useful extent. Its effect lessens as the square of the distance; thus, its warming effect at five feet distance, is twenty-five times less than at a distance of one foot. It is evident, therefore, that for long rooms, and for large assembly-rooms, a single source of radiant heat is quite inadequate; while, if the fire-places be multiplied, the heat in their vicinity is excessive. The immense loss of heat in our ordinary fire-places, is slowly leading to their modification; and although it is probable that radiant heat will always be the favourite source of warmth, it will doubtless be used as an adjunct to convection and conduction of heat.

The different sources of heat are employed, either singly or combined, in the following methods of warming our dwellings and other buildings:—

1. Warming by the open grate.
2. Warming by closed stoves.
3. Warming by hot-water pipes.
4. Warming by steam in pipes.
5. Warming by hot air.

Warming by electricity might have been added to the list, but, although seriously proposed by Edison, its expense renders it at present impracticable.

Warming by the Open Grate.—The old-fashioned English fire-place still retains its popularity, though it has undergone many modifications tending to increase its efficiency. As in it radiation is the source of heat employed, this mode of warming is scientifically the best, though far from being the most economical.

The **position of the fire-place** is important. It should not be on the external wall of the house, as thus a large proportion of heat is lost; but should be placed where the heat from the flue may be utilised in keeping up the temperature of the house.

The **construction** of an ordinary fire-place is also important. The ordinary construction is faulty in several respects. (1) The fire-place is commonly too far included in the wall, so that the heat at once passes up the chimney. (2) It is composed nearly entirely of iron, which rapidly conducts away the heat, and does not furnish a surface for radiation. (3) The bars and bottom of the grate are so arranged, that coal and cinders fall out in an incompletely burnt condition.

It is estimated that with an ordinary fire-place, seven-eighths of the possible heat is lost, one-half being carried up the chimney with the smoke, one-quarter carried off in the ascending current of warm air, and one-eighth of the combustible matter remaining unconsumed, forming the solid matter of the smoke.

The defects which have been indicated, may be remedied by

bringing the fire-place rather further out into the room; by substituting fire-brick for iron wherever possible; and by having a layer of fire-brick at the bottom of the grate, or the grate fixed to the floor with the intervention of a layer of the same substance.

The **shape of the grate** is important. The width of the back of the grate should be about one-third that of the front, the sides sloping out towards the front of the recess. The depth of the grate from before backwards should be equal to the width of the back. The sides and back of the fire-place must be made of fire-brick. This ensures the heat being retained in the grate; and it often will be given out for hours after the fire has gone out. And finally, the chimney throat must be contracted so as to ensure more complete combustion. The register as a rule is incapable of being fixed at various angles. In some grates, however, this can be done by means of a handle outside the grate, which is a great improvement. The **chief objections to an open fire-place** are (1) the great waste of fuel involved, even after the improvements indicated have been carried out. (2) The unequal heating at different distances from the fire. (3) The smoke and dust always produced to some extent, from accidental smoking of the fire, or from the escape of ashes. (4) The trouble involved in frequently replenishing the fire. (5) The cold draughts produced by the currents of air towards the chimney. These travel chiefly along the floor, when, as is commonly the case, the space between the bottom of the door and the floor forms the chief place for the entry of fresh air. Thus we may suffer from cold feet even when we are enjoying the glow of a warm fire.

The Fuel burnt in an open fire-place may be either coal or coal-gas. Occasionally coke is also employed. Coke and coal-gas have the advantage over coal, that (1) no smoke is produced. Coal-gas presents the additional advantages, that (2) it can be turned on at any moment, without having to go through a tedious process of lighting the fire; and that (3) the amount of heat can be exactly graduated by regulating the supply of gas. For continuous use,

however, in order to have a good cheerful blaze from a gas-fire, the cost involved is three or four times as much as for a coal fire. In experiments made at the Smoke Abatement Exhibition, it was found that to maintain 1° F. rise of temperature per hour coal costs about one-third the price of gas.

Open Gas-stoves are made in various forms. In the common one, small jets of gas are lit under the grate, which is filled with pieces of asbestos. This becomes red hot, and radiates a considerable amount of heat. In *Dr. Siemens' regenerative gas-stove*, there is an air-chamber behind the grate, in which in-coming air may be heated before being used to burn the gas. In this way, more complete combustion is ensured, and the heat is economised.

In another form of gas-stove, coke is burnt, the gas jets under the grate being employed merely to light the fire. This form is economical, but it is found that the ashes of the coke tend after a time to clog up the fire, and cause it to die a natural death.

In all the open gas-stoves we have yet seen, the air in the room becomes after a time unpleasant, and has a peculiar smell. This is probably due to the escape of some of the products of combustion, which owing to the absence of smoke are not readily perceived.

We have already mentioned some improvements in the open grate, in respect of shape and the employment of fire-brick. Other still more important improvements have been effected, such as the introduction of fuel from below, instead of at the highest part of the fire; the utilization of the heat from the fire-place and chimney to warm the air entering the room; and the shutting off of the draught of cold air under the grate.

(1) Many patents have been recently brought out, all agreeing in one respect, viz.: the **introduction of the fuel at the lowest part** of the fire. The uppermost part of the fuel being first burnt, and the remainder attacked from above, the smoke is consumed in passing through the red part of the fire. Thus, a comparatively smokeless fire is produced, and the amount of heat evolved is greatly increased. The production of *a comparatively smokeless fire* is a great boon.

Smoke means so much unburnt fuel, and not only so but the sooty particles float about in the atmosphere, rendering it impure, and changing comparatively harmless mists into town fogs, which are loaded with soot and the products of combustion, and do incalculable mischief to health and property.

(2) **The Utilization of the Heat Produced** in the fire-place, to warm the air on its way into the room, is another important means of improving the open grate. The way in which Galton's stove effects this has been already described. Other stoves are constructed on the same principle.

(3) In order to get the largest possible amount of heat out of a given quantity of fuel, it is advisable to **cut off some of the cold air**, which rushes through the fire, and carries the half-burnt gases and much of the heat up the chimney. This may be effected by having a solid fire-brick bottom to the grate, or as Mr. Pridgin Teale has pointed out, by closing up the front of the open chamber under the grate, by means of a close-fitting shield or door, which can be made by any ironmonger. In both plans, the entry of air into the fire from below is prevented. The "Economisers," as Mr. Teale calls them, appear to answer better than solid fire-brick bottoms, as they do not prevent the ashes falling under the grate.

Closed Stoves form the most economical and efficient warmers for rooms of moderate size. Coal, coke, and coal-gas are the fuels most commonly burnt in them. We shall first consider the closed stoves in which solid fuel is consumed.

The advantages rightly claimed for these are that (1) the amount of fuel consumed is small; (2) by adjusting the damper, combustion may be rendered as slow as desired, so that but little heat is lost by the flue or chimney; and (3) heat radiates from all parts of the stove into the room, and not simply from a small area of fire-front.

The chief objections to closed stoves are, that (1) they *dry* the air excessively, rendering it somewhat unpleasant. (2) They produce a peculiar *close smell*, which has been ascribed to the charring of minute particles of organic matter in the air, coming

in contact with the stove. If the air of the room is not heated above 75° Fahr., no smell is produced, and the relative humidity is not lessened to any appreciable extent (Parkes). But when the heat produced by the stove is excessive, these results do follow. The unpleasantness may be modified though not entirely removed, by placing shallow pans of water near the stove.

(3) Portions of the *products of combustion* may pass through cracks or fissures in the stove, or even through the joints of the stove. Independently of such accidental cracks, cast-iron stoves, when red hot, appear to allow gases to pass through them with comparative ease. Thus carbonic oxide and other gases may find their way into the room, and it is probable that this rather than the dryness of the air, is the cause of the unpleasant symptoms sometimes complained of in rooms where closed stoves are in use. Dr. Bond has proposed a coating of silicate to prevent the deleterious gases finding their way through the stove.

Many modifications of the older closed stoves are now in common use. One of them is shewn in *Fig. 21.* In general construction it resembles George's Calorigen, coal being substituted for gas. Excessive heating of the air is prevented by the presence of two air chambers, only the outer one, which brings external air to be warmed, having its air emptied into the room.

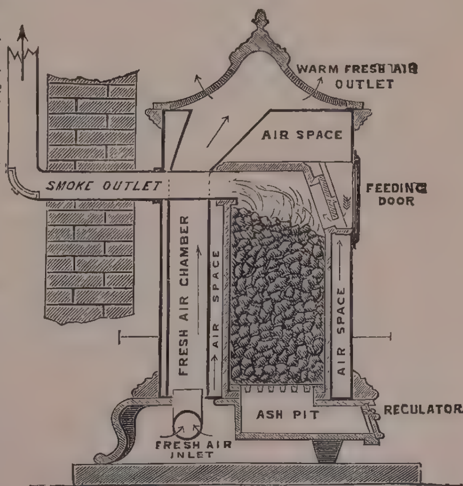


FIG. 21.
SLOW COMBUSTION CALORIGEN.

Messrs. Doulton also make a number of slow combustion stoves, which like the last, seem to be quite free from the objections urged against many closed stoves, besides being ornamental.

Gas may be burnt in a closed stove instead of coal or coke. These may be very pernicious, or if properly constructed may actually help in ventilating a room.

The gas-stoves to be specially avoided are those *without a flue*, for the escape of the products of combustion. One occasionally sees misleading advertisements to the effect that "no flue is necessary;" "the products of combustion are turned into water;" "entirely free from smell and smoke;" which last is a pity, as otherwise unwary people would be less likely to be poisoned without knowing the source of their troubles. No gas-stove without a flue is safe, unless some special measures are used to absorb the poisonous gases by lime-water, or some other substance. The light copper-fronted stove, and the platinum and asbestos stove employed to hang on the front of the grate, are perhaps the most injurious, and to be specially avoided.

Gas-stoves which also act as ventilators are by far the best. Of these we may mention George's Calorigen already described, and a number of others constructed on similar principles.

Warming by open grates or closed stoves is specially applicable to the rooms of private houses; warming by hot air or steam, or hot water, is chiefly used for large buildings. It is quite possible that these methods will be applied at some future time on a large scale to the warming of private houses. In some large towns of the United States, this has been already done, blocks of a hundred or more houses being warmed from the same centre, by the same system.

But apart from such a central system, hot air and hot water lend themselves to the heating of houses on what may be called the *Whole House System.* We have mentioned in the last chapter some methods of doing this, and must now describe others.

Hot-water Pipes are probably the best means of carrying heat

to various parts of a large house, and hot water is more thoroughly under control and less dangerous than either hot air or steam. There are *two systems* of heating by hot water.

In the first, which we may call the *low pressure system*, there is a boiler from which water circulates through pipes to every part of the building, and as it cools down returns again to the boiler. At the highest points of the pipes, outlets are provided for air. In this system the water is not heated above 200° Fahr., and there is consequently no great pressure on the pipes.

In the *high pressure system* (Perkin's patent), the pipes have an internal diameter of about ½ an inch, and have thick walls made of two pieces of welded iron. There is no boiler, but one portion of the tube passes through the fire, and the water is heated to 300—350° Fahr., thus subjecting the pipes to great pressure. In dwelling-houses with the low pressure system, for every 1,000 cubic feet of space to be warmed to 50°, 12 feet of 4-inch pipe should be given; with Perkin's pipes, probably about two-thirds of this will suffice.

The means by which hot-water pipes, without any elaborate apparatus, can be made to subserve the interests of ventilation, have been already described.

Steam Distributed by Pipes may be employed instead of hot water. The Houses of Parliament are warmed by steam-pipes in a chamber under the floor. This method is chiefly applicable, however, to factories where there is a surplus supply of steam. It is not so safe nor so equable in temperature as hot water.

Warming by Hot Air is only applicable on a large scale, and even here one cannot help doubting its healthiness. It necessitates the carrying on of an artificial system of ventilation conjointly with it, and practically forbids the opening of windows. The entering air is heated by passing it over the flue of a furnace. It is then carried by various flues to different parts of the building, opening at the floor by means of a grating. The air at the gratings is generally intolerably hot, and often presents a degree of

humidity much too small for purposes of health. In addition, the flues are out of sight, and it not uncommonly happens that the ventilating flues communicate through some crack with the furnace flue, and that consequently, carbonic oxide, sulphurous acid, etc., are discharged into the building. The trust in artificial means of ventilation is also productive of evil in another way; for with a high internal temperature, air tends to be sucked from water-closets or drains, instead of from more legitimate sources.

Boyle's Patent Air Warmer is a simple means of warming the fresh air entering into a room, where there is no open fire-place, and when steam or hot air or water pipes are not available. It consists of a copper or iron pipe, about $1\frac{1}{2}$ inches in diameter, which is placed within an inlet ventilating tube, preferably of the form of a bracket. This tube is turned upon itself, as shewn in *Fig. 22*, thus obliging the incoming air to impinge upon it repeatedly in its passage from below upwards. At the lowest part of the tube is a small chamber C, which contains a small Bunsen's burner, the flame of which plays up into the lower end of the tube. The heat produced by the com-

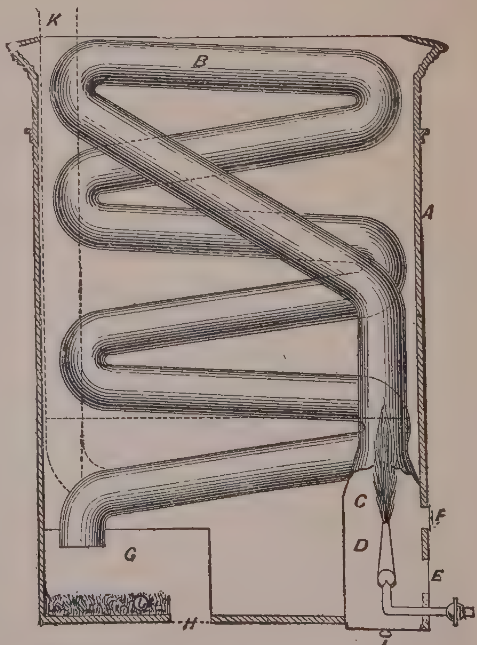


FIG. 22.
BOYLE'S PATENT AIR WARMER.

bustion travels throughout the length of the pipe, which at its further end dips into a condensation box G, containing a quantity of loose charcoal intended to absorb the products of combustion. The charcoal should be frequently renewed, as its absorptive power soon disappears. A much better arrangement is to carry the pipe, as shewn by the dotted line, to K, which leads into a flue or extraction shaft. At E is an opening covered with perforated zinc, for the purpose of supplying air to the burner. At F is a sliding door, through which the gas is lit.

When the tubes are placed against wood-work, they ought, in order to avoid any danger of fire, to be fitted with a double casing, the space between being filled in with asbestos or some other non-conducting material.

CHAPTER XXIII.

CLOTHING.

Loss of Heat by the Skin and Other Organs.—Requisites of Dress.—Relation of Dress to Perspiration.—Evils of Tight Clothing.—The Materials Used.—Amount of Clothing Required by Old and Young.—Poisonous Dyes in Clothing.

Physiological Considerations.—The average temperature of the surface of the body in man is 98·4 to 98·6°. It varies within slight limits, but not more than one degree. The maintenance of a tolerably uniform temperature is an essential condition of life. The factors governing the temperature of the body are *the amount of heat produced* and *the amount lost.* If more heat escapes, more has to be generated; and the source of all the heat produced in the body is the food taken. This becomes oxidised in the body, and the chemical oxidation produces heat. The more copious the supply of oxygen (by respiration) and the more complete is oxidation. Hence, we find that in birds, whose respiration is very active, the temperature is higher than in ourselves.

Heat is lost, (1) by the *skin;* (2) in *respiration*, the expired

air having been heated during its stay in the lungs; (3) with the *food and drink* taken, if not at the temperature of the body; (4) with the *excreta;* and (5) by transformation of heat into *mechanical motion.* Of the whole loss by these different channels, probably eighty to ninety per cent. is through the skin.

The Loss of Heat by the Skin is in three different ways. First, by *conduction*, when the skin comes in contact with anything cooler than itself; secondly, by *radiation* into space; and thirdly, by *evaporation* of the perspiration. The last cause produces a considerable reduction of temperature, even when the perspiration is not so abundant as to be visible, but is in the form of insensible perspiration. The losses by these different sources vary in amount; when one is increased, another is diminished, by way of compensation. Thus, in very cold weather, the amount of radiation and conduction of heat are increased; but evaporation greatly decreases, and the diminished loss of heat in this respect counterbalances in some degree the increased loss by radiation and conduction.

When the external warmth is considerable, increased evaporation occurs; while when the weather is cold, the cutaneous arteries become smaller, and less blood goes to the skin, and so the loss of heat is diminished. In most climates, however, this action of the skin requires supplementing by some kind of clothing.

Requisites of Dress.—1. The first and most important requirement is, that *clothing should maintain a uniform and equable temperature* in all parts of the body.

In hot climates clothes are required in order to protect the body from external heat. In this country, they are required to prevent the too rapid escape of heat from the body. For both these purposes, dress must be of a non-conducting material, and one which does not encourage radiation into the surrounding atmosphere.

The loss of heat by the skin may be prevented by interfering with radiation or conduction of heat, or with evaporation from its surface. Radiation of heat from the skin is prevented by clothing, the dress taking the place of the skin as a radiating surface. The

amount of radiation from the dress will depend on the rapidity of conduction of heat from the skin. The amount of conduction and of radiation of heat will vary considerably with the *material* and *colour* of the dress.

As regards conductivity, the two extremes are represented by linen and fur. It is found that if the conducting power for heat of linen = 100, then that of wool = 50 to 70. This partly explains why woollen goods are so much warmer than linen. We shall find that there is another explanation in the comparative hygroscopic properties of the two materials.

As regards radiation of heat, in one experiment it was found that while a piece of linen took $10\frac{1}{2}$ minutes to cool, a corresponding piece of flannel took $11\frac{1}{2}$ minutes.

Apart from the material, the *colour of dress* has some influence in regulating the loss of heat. Dark-coloured materials absorb more light and heat than lighter coloured materials; they may be good or bad conductors of heat, according to the nature of the material. White reflects the rays of light and heat; hence it is a poor absorber. In summer it prevents the passage of heat inwards, and, in winter, may prevent its passage from the body. It is thus well adapted for both winter and summer clothing, and has the additional advantage of being the cleanest colour.

Franklin placed a number of squares of different coloured cloths of the same material on snow, and found after a time that the snow covered by the black piece was most, and by the white piece least melted. In another set of experiments, shirting materials dyed various colours were taken, and it was found that if the rays of heat received by white were represented as 100, pale straw received 102, dark yellow 140, light green 155, Turkey red 165, dark green 168, light blue 198, black 208.

The influence of colour is antagonised to a large extent by the nature of the material; the increased heat absorbed by a dark material may be counterbalanced by the material being a good conductor. Also the influence of colour is only exerted

superficially; hence, although it produces considerable effect in thin textures, as gauze, it has little influence on thick materials.

2. *The dress should not interfere with perspiration.* In order that it may not do this, it should be competent to absorb moisture easily, without its surface becoming wetted. Those materials which become soon wetted by perspiration, that is, have poor hygroscopic properties, are comparatively cold, inasmuch as water or any moist material is a good conductor of heat. Pettenkofer found that while the maximum hygroscopic power of wool (flannel) is 174 and the minimum 111; the maximum of linen is 75 and the minimum 41. Hence, with a flannel dress next the skin, the liability to chill is much less than with a linen one. There is one slightly counterbalancing drawback; hygroscopic materials absorb moisture from the air, as well as from the skin. An ulster overcoat during a damp day, without rain, increases considerably in weight.

But although woollen and similar materials diminish the risk of chills, they do not remove it entirely, especially when the perspiration is excessive. Catching cold often occurs in this case. This is especially apt to occur during sleep, or after taking a warm bath, or when perspiring after exercise. In the latter case it is important not to sit in a cold room or exposed to a draught, and if possible to rub the chest with a rough towel, so as to free it from perspiration.

Waterproof clothing is injurious when worn beyond a short period, on account of its being non-porous and consequently keeping the body enveloped in a vapour bath composed of its own perspiration. For a similar reason India-rubber boots are objectionable, except for short periods; they make the feet damp, and even sodden. Sealskin jackets are objectionable for walking, not only because of their weight, but because they are not porous.

3. *The warmth of clothing should be uniformly distributed* throughout the body. This principle is very frequently departed from; and consequently one part may be chilled while another is over-

heated. This is seen especially in female apparel; petticoats are piled one over the other in the lower part of the trunk, while the neck and upper part of the chest are left comparatively bare, and the legs are but imperfectly protected. The same evil is seen in the short sleeves, and short and low-necked dresses of young children. The adoption of "combination" garments for women, and of sleeves and leggings for young children, is a most desirable reform, and one which will doubtless greatly diminish the diseases due to exposure to cold.

4. *The clothing should not be tight;* and this for three reasons. First, because *loose clothing is warmer* than tight; this everyone has experienced in the case of gloves. The retention of air in the meshes of clothing is one of the main causes of its warmth. Air is a bad conductor of heat; the tighter the clothing, the less air it contains in its meshes, and consequently the cooler it is. The imprisonment of air in the meshes of the material largely explains the warmth of eider-down quilts, furs, and flannels as contrasted with linen.

Secondly, clothing should not be tight, in order *to avoid interference with the action of muscles.* Tight sleeves prevent the muscles of the arms and chest from being exercised. Tightly laced corsets imprison the trunk muscles, prevent their contractions, and so lead to muscular weakness and occasionally spinal curvature. Tight skirts similarly prevent free play of the lower limbs, leading to a halting gait, a diminished amount of exercise, with all the evils following deficient exercise. Tight clothing is however not confined to one sex, and in all cases leads to hampered movements and deficient muscularity.

Thirdly, tight clothing tends to *impede the functions of circulation, respiration, and digestion.* The fashion which more than any other interferes with important functions is *tight-lacing.*

This produces (1) compression and displacement of the viscera; the liver and the stomach especially suffer. (2) Respiration is interfered with, the action of the diaphragm being impeded. (3)

Circulation is to some extent obstructed, and so we get the fairly characteristic bluish-red nose of tight-lacing. (4) The muscles of

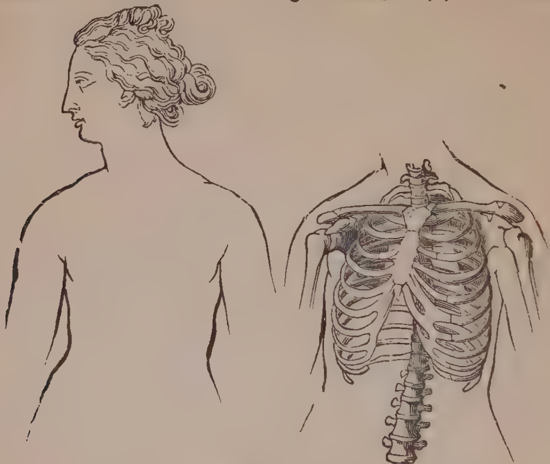


FIG. 23—THE NATURAL FIGURE.

the trunk being tightly encased, are incapable of movement, and consequently tend to waste and atrophy. (5) The general outline

FIG 24.—THE FIGURE PRODUCED BY TIGHT-LACING.

of the body is altered. Instead of the waist being elliptical, as it naturally is, it becomes nearly circular; and instead of its circumference averaging twenty-six to twenty-seven inches, it is eighteen to twenty-one inches, or even less.

Garters are another constricting agency to be carefully avoided. Varicose veins may be caused by them, and not uncommonly cold feet, from the impeded circulation. Stockings are best supported by suspenders from the waist.

Tight sleeves and skirts, by restricting the movements of the limbs and so preventing proper exercise, are likewise injurious.

Tight boots, again, are injurious, as they tend to destroy the natural elasticity of the movements, and confine them within narrow limits. They act to some extent the part of splints. During childhood they are very apt to produce permanently weak ankles. Moreover, by interfering with the circulation of blood through the feet, they cause cold feet, and not uncommonly chilblains. *High-heeled boots* are extremely injurious, as they do not allow the natural elasticity of the foot to come into action. This accounts for the uncertain and ungraceful gait of many ladies. Supposing the heel of the foot can rise six inches from the ground in walking, if the boot-heel props it up $1\frac{1}{2}$ inches, the extent of possible movement is reduced to $4\frac{1}{2}$ inches. High heels throw the weight of the body on the front part of the foot; the consequence is that the balance of the body is disturbed, and more strain is thrown on the spinal muscles. This may result in spinal curvature, in extreme cases; while corns and bunions are common consequences. Supporting the skirts from the waist alone is injurious, as important organs are compressed and displaced; this effect is not entirely prevented by fastening them over the corset.

5. *The weight of the clothing should be the smallest amount consistent with warmth, and it should be evenly distributed.* The chief weight should not be suspended from the waist, as here the parts are not well supported by bones. The shoulders and hips should share in the suspension of clothing, thus diminishing the

danger of compression and displacement of internal organs. In order that clothing may be as light as possible, it should be made to fit to each limb separately, thus diminishing the amount of material required. The protection from cold afforded by petticoats is at the best fortuitous; and a much smaller quantity of clothing fitted to the limbs is equally warm.

6. *The materials of dress should be as far as possible uninflammable.* This may sometimes be disregarded, but is often important, as in the nursery. In this respect, as in many others, wool possesses great advantages. Woollen fabrics smoulder rather than burst into flames, and thus the injury resulting from any accident is limited. Cotton is more inflammable than linen, linen than silk, and silk than wool. A closely woven cloth is less inflammable than one with open meshes. Women's apparel is most liable to be set on fire, and especially if crinolines and long trains are worn. A muslin dress, *plus* a crinoline, is one of the most dangerous combinations. A long cotton pinafore is a common source of burning among children, when playing near the fire.

Dress materials, and more particularly muslin, have been rendered non-inflammable by treating with a solution of ammonic phosphate, or ammonic phosphate and ammonic chloride mixed. The best material, however, is sodic tungstate, which, unlike the others, is not affected by ironing. Sodic molybdate is used in arsenals to render the workmen's clothing non-inflammable. All the above plans are objectionable, as the weight of the material is increased 18 to 29 per cent., and they all wash out. To remedy this, a "fire-proof starch," containing sodic tungstate has been devised.

Perfect non-inflammability is only required in certain dangerous occupations. The plans hitherto mentioned simply prevent the fabric breaking out into flame. The only cloth absolutely unaffected by fire is asbestos cloth.

7. *Elegance of dress*, although not so important as utility, is not to be neglected, and the two are perfectly compatible. In fact,

elegance is indirectly associated with utility, for nothing which is awkward, or leads to obstructed movements or distortions of the body, is really elegant. A sudden constriction, as in a very tight waist, is not only bad from a hygienic point of view, but is also ugly.

Materials for Clothing.—The materials used are derived partly from the vegetable world, as hemp, flax, cotton; and partly from the animal world, as silk, wool, hair, feathers. The most important materials are wool, silk, cotton, and flax.

1. *Wool* varies somewhat in character, according to the animal from which it is derived. In all its varieties, however, it preserves the character of a bad conducting and porous substance, the two most important requisites in a dress material.

(1) Wool from the sheep is really a soft and elastic hair, composed of fibres three to eight inches long, and about $\frac{1}{1000}$ inch thick. The finer and shorter wools are used for fine cloth, the longer and coarser for "poplins," "worsted pieces," etc. Flannel is a woollen stuff of rather open and slight fabric. Wool is irritating to delicate skins, and may be so much so, that it cannot be worn next the skin, whether as flannel, worsted, or merino. In these cases, it may be worn outside a linen or gauze vest, and so all its advantages secured. It is one of the worst conductors of heat, and ought always to be worn in winter; while even in summer, it ensures a greater immunity from chill after perspiration than any other material.

(2) *Cashmere* is made from the down found about the roots of the hair of the Thibet goat. Imitation cashmere is made of various materials mixed together.

(3) *Alpaca* is obtained from the fleece of the llama, alpaca, and vicuna. It is longer than the fleece of the sheep, the fibres, which are soft and strong, averaging six inches in length. It is commonly made up with cotton or silk.

(4) *Mohair* is the hair of a goat inhabiting the mountains near Angora. It is woven into an almost waterproof cloth, and used in making plush, braid, etc.

2. *Hair* derived from the horse or cow differs from the hair usually called wool, in the greater solidity of its structure, which makes it ill-adapted for clothing. Its chief use is in the manufacture of felts, of which hats are made.

3. *Leather* is a kind of natural felt, very close and firm in its texture. It is used in this country chiefly for boots, but in some colder climates also for coats, etc. It is impervious to moisture, like sealskin, and is consequently not very healthy. The same objection applies to *chamois-leather underclothing*, which is non-porous, and consequently keeps the skin hot and clammy; also, it cannot be washed without becoming stiff on drying. This necessitates wearing the material after it has become impregnated with excretory matters from the skin.

4. *Silk.* The thread spun by the silk-worm is composed of filaments $\frac{1}{2000}$ inch wide, and is the strongest and most tenacious of textile fabrics. Its thread is three times as strong as a thread of flax of the same thickness, and twice as strong as a thread of hemp.

Its fibres are round like those of linen, but softer and smaller; it gives an agreeable sensation of freshness to the skin even more than linen. It is a worse conductor of heat than cotton or linen. Its great disadvantage for wearing next the skin, apart from its expense, is that it irritates delicate skins, and may even produce a rash on the skin.

Satin is silk so prepared as to form a smooth, polished surface.

Velvet is a silk fabric of which the pile is due to the insertion of short pieces of silk thread under the weft or cross-thread. Cheaper kinds are made, containing a certain proportion of cotton.

Crape is made of raw silk gummed and twisted to form a gauze-like fabric. Taffety, moire, brocade, and plush are made of silk alone or combined with cotton.

5. *Cotton* consists of the downy hairs investing the seeds of the gossypium plant. The threads of which it is composed are flat, ribbon-like, and twisted, about $\frac{1}{800}$ to $\frac{1}{2000}$ inch wide. Owing to

its flat fibres with sharp edges, it is apt to irritate delicate skins; linen is always preferred for dressing wounds for a similar reason. Cotton is warmer than linen, being a worse conductor of heat. It also absorbs moisture better, not becoming wet so soon; but it lacks the "freshness" which makes linen materials pleasant to wear.

Calico, fustian, jean, velveteen, and muslin are the chief cotton fabrics.

6. *Flax* is formed from the fibres of the flax plant. Linen is made from it. Cambric and lawn are very fine and thin linen materials. The fibres of linen are round and pliable: thus it is smooth and soft, and peculiarly agreeable to the skin. It is, however, a good conductor of heat, just the opposite of what a warm dress ought to be. In consequence "it feels cold" to the skin. In addition, its fibres, being porous, attract the moisture of perspiration, the air in the pores being displaced. As water is a much better conductor of heat than air, a feeling of general chilliness results. Most of the advantages of linen and flannel combined, may be obtained by wearing linen next to the skin, and flannel outside this.

7. *Mackintoshes* are valuable as a temporary protection against external wet. Worn for more than a short period, they produce great heat and a sense of closeness, owing to retention of the perspiration. They would be cool were it not for their impermeability to moisture, as they are good conductors of heat.

The best form of mackintosh is that having a cape, with a space for evaporation between it and the rest of the garment. It is also preferable to wear a mackintosh in which the waterproof material is outside, uncovered by a thin cloth, so as to simulate an ordinary overcoat; as the latter increases in weight when it becomes wet.

The Amount of Clothing required varies with circumstances. 1. *Health;* those of robust constitution require less than the feeble. The more active are digestion and assimilation, the less is the amount of clothing required. It is well to remember that if heat is preserved by clothing, less food is required. Thus a distinct

saving of food is effected by warm clothes. Warm clothes are the equivalent of so much food that would have been required to keep up the temperature of the body, if the clothes had not been worn. This is well shewn in cases of starvation, as after a shipwreck. Thinly clad persons in such situations die much more quickly than those who are better protected.

2. *Climate and season.* Clothing requires to be adapted to these. In winter and in cold climates the amount of clothing must be increased, and warmer materials chosen. In the changeable climate of Great Britain, it is difficult to adapt the character of one's dress to the requirements of each day, or even to various parts of the same day. It is important, however, to remember that *clothing ought not to be changed according to the calendar*, but according to the weather. The tendency is to assume summer clothing too early in the spring, and to continue it too far into the autumn. The sudden changes of temperature in autumn and spring are particularly dangerous, and should be guarded against by flannel. According to Boërhave, winter clothing should be put off on Midsummer day, and resumed the day after. This, although rather exaggerated, may serve to impress the caution required. The same authority says that only fools and beggars suffer from cold, the latter not being able to procure sufficient clothes, the former not having the sense to wear them.

3. *Age.* Those at the two extremes of life are specially susceptible to cold. The mortality of infants during the first few months of life is nearly doubled in winter. It has been said that one-sixth of the deaths of young children result directly or indirectly from cold.

After the age of thirty-five, it is better to exceed than to be deficient in clothing. A degree of cold that would act as a useful tonic to the robust and middle-aged, produces serious and even fatal depression of the vital powers in children or aged people. For the same reason it is advisable to discontinue cold baths as age advances.

A very pernicious delusion is prevalent, that children ought to be "hardened" to the influences of cold, and that too much clothing "makes them tender." Excessive clothing may possibly increase the tendency to "catch cold," owing to its exciting perspiration, or owing to the fact that the extra clothing is commonly thrown off at irregular intervals—witness the effects of wearing a scarf round the neck occasionally. But to suppose that children can be hardened by exposure of arms and legs, and other parts of their bodies, is irrational. A large amount of heat is lost from these bare surfaces, and apart altogether from the danger of chill, more food must be taken to compensate for this loss of heat, and keep up an equable temperature. Also if the food taken is expended in preserving the warmth of the unprotected body, less material is left for the purpose of growth. From these causes it frequently happens that children remain stunted in growth, even if latent disease is not actually developed by the extra strain on their resources.

Gutter children are often pointed to as demonstrating the power of hardening. It is forgotten, however, how many of these poor children have perished under the hardening system, and that the good health of those remaining is in spite of the hardening—is, in fact, due to the survival of the fittest.

Poisonous Dyes in Clothing.—These, like poisonous wall-papers, were formerly much more common than at present, and, as in wall-papers, the poisonous agent has most frequently been arsenic, large quantities of which are used in the preparation of certain dyes. *Magenta*-coloured materials have been the most common source of poisoning, and it has generally been found that the material contains arsenic—in some analyses as much as 2 per cent. of arsenic trioxide and 7½ per cent. of arsenic pentoxide.

A few years ago many cases of poisoning were produced by *coralline*, which forms a brilliant red dye; probably here the active cause was arsenic.

Scheele's green (arsenite of copper) has been occasionally employed

to dye fabrics green, and it is extremely noxious, as it is apt to get rubbed off and inhaled by others as well as the wearer.

Cochineal red is said sometimes to contain an injurious amount of arseniate of alumina. When a fabric dyed with this is worn next the skin, the latter becomes red and inflamed, and may even ulcerate, severe constitutional symptoms being also produced.

Yellow and orange chromates of lead have been used for dyeing clothing materials, and would doubtless be very injurious.

There is scarcely any material worn next the skin, which has not been at one time or another the means of poisoning the wearer. A red "chest protector" has produced a copious rash; and arsenic poisoning has followed the wearing of red flannel shirts. Red socks and stockings have occasionally produced inflammation of the feet. Occasionally black silk gloves have produced inflammation of the skin of the hands, and still more frequently those lined with magenta-coloured wool. Shoes lined with yellow leather have produced a copious rash on the feet, though the nature of the poison in the leather does not seem to have been ascertained.

The means of detecting arsenic in any fabric or wall-paper, will be described in Chapter XXIX.

CHAPTER XXIV.

HOUSE DRAINAGE.

The Amount of Sewage.—Rain-water Pipes.—Bath-room Pipes.—Disconnection from the Drain.—Sinks.—Water-closets.—Varieties of Water-closets.—The Soil Pipe.—Ventilation of Soil Pipe.—The House Drain.—Traps.—Insecurity of Traps.

The Removal of Impurities.—In order that health may be maintained in any inhabited house, it is essential that the impurities, that is the excreta, necessarily connected with animal life, should be removed. These excreta may be divided into two classes,—the first including the gaseous and volatile products

evolved from the lungs and skin; and the second, the liquid excretion from the kidneys, and the solid from the bowels. The former are got rid of by efficient ventilation; the latter, ought to be as quickly removed, but require more elaborate arrangements to ensure this.

The **average daily amount** of solid excreta is about 4 ounces, and of fluid excreta about 50 ounces for each adult male. Taking all ages and both sexes into consideration, Letheby gives the mean amount per head as 2·784 ounces of fæces and 31·851 ounces of urine.

When urine and fæces are mixed, after a variable interval they begin to decompose, ammonia and fœtid gases being disengaged in large quantities. In analyses of sewer-air the chief gases found were carbonic acid, nitrogen, carburetted hydrogen, sulphuretted hydrogen, and carbo-ammoniacal volatile compounds.

In addition to the excreta, house-slops have to be got rid of, and "dust." **House-slops** vary greatly in quantity, but probably amount to as much as sixteen gallons per head daily. They consist chiefly of the water used in cooking and washing and for baths.

The **Dust** consists chiefly of the ashes from fires, but the dust-bin also forms a favourite refuge for kitchen refuse, composed of various animal and vegetable matters, as well as for broken pots and tins. It is dealt with apart from the house-slops and excreta, except in certain dry methods of disposal of sewage.

Two chief plans of getting rid of the sewage have been proposed, though there are many varieties of these. They are—

1. The Water Method, and
2. The Dry Methods.

Each of these has its advocates, and with both a good result can be obtained. For large towns, however, the water carriage of sewage is preferable, and in this chapter we shall confine ourselves to the part of this system, which relates to the **Drainage of the House.**

The chief appurtenances of a house, which empty their contents into the drain and thence into the street sewer, are—(1) Rain-water Pipes; (2) Bath-room and Sink-pipes; (3) Water-closets; (4) Soil-pipes; and (5) The House Drain. We will consider these in detail.

Rain-water Pipes collect the water from the roof by means of gutters, and carry it down to the house drain, except in the few cases in which the rain-water is collected for use. The connection with the drain may be direct, the rain-water pipe opening into the drain, with or without the intervention of a syphon trap. In either of these cases, though chiefly when there is no trap, foul gases ascend the pipe; and if the upper end of this is near a window, they are blown into the house, and thus form an occasional cause of diphtheria, sore-throat, and other diseases. When there is a trap, the rain-water pipe tends to become blocked by leaves or other matters washed down from the roof, and then water overflows the gutter and runs down the side of the house. It is evidently preferable, therefore, for rain-water pipes to end a short distance over a grating, which communicates with the drain. In this case, if sewer-gases, by any failure of the trap, escape, instead of mounting the water-pipe, they become diffused in the atmosphere outside the grating; and foreign particles are intercepted before they can block up the junction with the drain. The opening in the yard, into which the rain-water falls, should be provided with a water-trap, which prevents the escape of sewer-gas from the drain. A syphon-gully, with a galvanised iron grating, is a good form for this purpose, though a *Bell Trap* is commonly employed. The latter ought, on no account, to be allowed. It consists of a perforated plate, which has a bell-shaped piece of iron fastened on to its under surface. The edge of this piece of iron, when in position, lies below the surface of the water contained in the iron trough. Thus, water flows through the perforated plate, and under the edges of the bell, into the drain below. The chief objections to this form of trap are that (1) the water in the trap tends to become dry, unless the

fall of rain is frequent; the exit of sewer-gas is then easy. (2) When the bell is taken off or injured, the way to the drain is direct.

Occasionally rain-water pipes are joined directly with the soil-pipe. This is advantageous for the soil-pipe in two ways: it is occasionally flushed with water; and in the intervals of rain, the water-pipe acts the part of a ventilator, relieving the pressure of sewer-gases in the soil-pipe. But this plan cannot be recommended. For when there is a heavy fall of rain, the ventilating action of the rain-pipe ceases, and the gases contained in the soil-pipe are driven in some other direction, often through defective traps into the house. And even when it acts as a ventilator, the top of the rain-pipe is often near some window, and impure gases are wafted in at the staircase, or into the servants' bed-rooms. Or when this is not the case, the cistern may be near at hand, and the water in it eagerly absorbs the poisonous effluvia.

Instead of allowing the rain-water to run directly on to a grating and thence into the drain, it may be collected into flushing cisterns, and emptied periodically into the drain. This is especially important when the outfall into the street-sewer is not good, or in large establishments, however good the fall may be.

The *flushing cistern* should be constructed to empty itself automatically, when its contents attain a certain depth. This is effected by Field's annular syphon, and other cisterns by various makers.

The *overflow-pipe from the cistern* should be made to end directly in the external air on the leads, so as to join the rain-water pipe. It must on no account be joined to any part of the water-closet system.

The Bath-room Waste and Over-flow Pipes are very frequently carried directly into the soil-pipe, thus helping to keep the latter properly flushed, but at the same time ventilating it into the bath-room. In some cases this is ostensibly prevented by a syphon bend

in the waste pipe from the bath. This does not answer the desired end; for if the bath is not frequently used, the water in the trap dries up, and then the connection between the bath-room and the soil-pipe is direct; and if this does not occur, sewer-gas may be absorbed by the water in the trap, and given up on the other side to the air of the bath-room. The waste-pipe of the bath (and the same applies to its over-flow pipe) ought either to open into the rain-pipe, or be carried down to the outside of the house, and open a short distance above a grating with a syphon gully attached, like the rain-water pipe.

Under the bath is usually placed a leaden tray, called a *safe*, to catch any accidental spillings of water. The small pipe leading from this must not be connected with the soil-pipe, or in any way directly with the drain. It is preferable to allow it to open in the external air, and have it so far prolonged, that if there is any leakage, the water will not run down the sides of the wall.

The importance of attention to these rules is very great. The bath-room is a frequent source of poisoning by sewer-gas, and especially so now that bath-rooms are commonly made to communicate with bed-rooms. The danger is still further increased if the bath-room contains a water-closet.

Sinks are not uncommonly the source of offensive smells, when made of stone. The use of a clean and hard glazed sink, such as the one shewn in the accompanying figure, is much to be preferred.

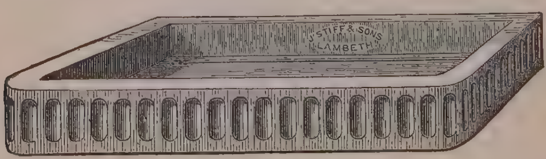
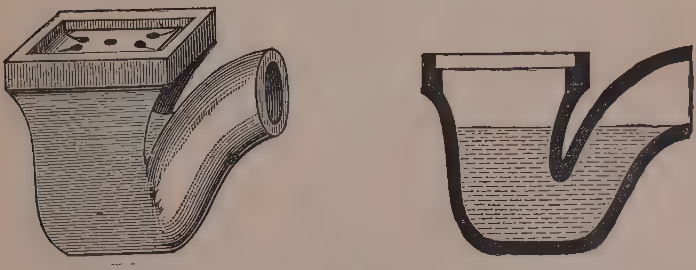


FIG. 25.
STONEWARE KITCHEN SINK.

The sink should, where possible, be placed against an external

wall, as it is then much easier to carry the waste pipe outside the house. Very commonly, the sink pipe passes directly into the drain, the only thing preventing the entry of sewer-gas into the kitchen being a bell-trap at the sink. The futility of this in preventing the passage of sewer gas has been already shewn. In addition, if any obstruction to the flow of water occurs, the bell is removed, and foul gases ascend into the house, with sad results in many cases as regards health. Occasionally a syphon trap is substituted for the bell-trap, being placed just under the sink. This is better than the bell-trap, but alone is not a sufficient safeguard. The syphon should have an inspection opening at its lowest point, fitted with a screw cap, so that it can be cleansed if necessary.

The safest way, however, of preventing the entry of sewer-gas into the kitchen, is to disconnect the sink-pipe from the drain, making it open over a grating, below which is a water trap, as in the case of the rain-water pipe. The best trap for this purpose is the stoneware gully-trap (*Fig. 26*).



A — STONEWARE GULLY-TRAP.

FIG. 26.

B — SECTION OF THE SAME, SHEWING A WATER-SEAL 3 INCHES IN DEPTH.

This trap is connected with the socket of the first drain-pipe, and the junction can be made water-tight by means of a cement joint. On this account, and because it gives a better water-seal than the bell-trap or D trap, it should be always used.

Water-closets require to be skilfully constructed and well-situated, if they are not to become nuisances and fertile causes of disease. In building a house, the *position* of the closet should be carefully considered. In all cases it should be in an out-standing part of the house, and against the external wall. Instead of this, one commonly finds it in any convenient recess, abutting on a bed-room, or where it cannot be properly ventilated. Usually the closet is placed at the back of the house; and as the main-sewer is often situated in the street, as a necessary consequence the soil-pipe has usually to pass under the house. This is a bad arrangement, and should be avoided when possible. The closet should be connected with other parts of the house by a passage, and an inner door should separate it from them.

As bad gases tend to ascend, a closet on an upper floor is preferable. There should be no closet on the same floor as the kitchen. Water-closets in bath-rooms are very liable to be a source of danger, unless the hygienic arrangements are perfect.

The *ventilation* of the closet should be good—if possible, by two opposite windows. If there is only one window, it is advisable to have a perforated brick or iron grating in the wall. If there are several water-closets, they should be directly over one another, and the junction between the pipes should be curved, and not at a right angle.

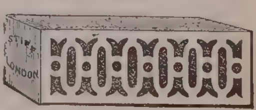


FIG. 27.
PERFORATED VENTILATING BRICK.

The *water-supply* to the closet should be abundant. Every flush of water should be sufficient to carry the contents of the basin through the soil-pipe into the sewer. The quantity allowed

by the Water Companies in London is two gallons, which is barely sufficient for this purpose. The source of the water-supply is commonly either the main water-pipe or the drinking-water cistern, the latter mode of supply being shewn in *Fig. 2.* Both these plans are dangerous as they occasionally lead to the contamination of drinking water with effluvia from the closet, if not also with sewer gases. Each closet should have a separate cistern or service-box; and it is a good plan to have water-waste preventers, by means of which a certain quantity of water, and no more, can be discharged each time the handle is pulled. For wash-out or hopper closets, one of the best of these is the *syphon waste-preventer* shown in *Fig. 28.* When the handle of this is

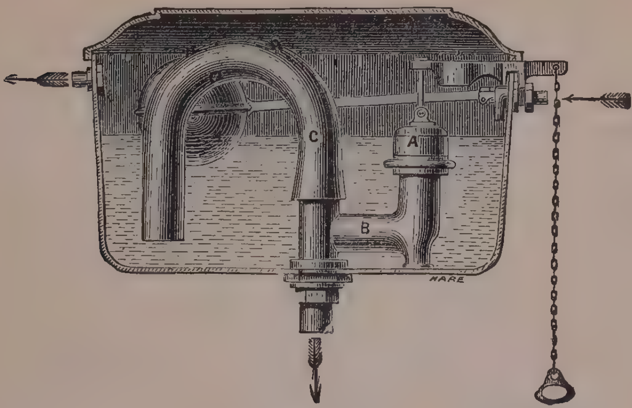


FIG. 28.

SYPHON WASTE-PREVENTER.

pulled, the whole of the water in the cistern is syphoned out by the syphon C and carried down to the water-closet, whether the handle be held down or not. The amount of fall from the cistern to the closet should not be less than three or four feet, in order to ensure a thorough scouring of the soil-pipe; and the flushing-pipe should have an internal diameter of not less than $1\frac{1}{2}$ inches. It is

commonly supposed that a small flow of water, trickling continuously down a closet, tends to keep it clean, and prevent smells; but the water thus used is simply wasted. Others fasten up the handle of the closets occasionally, so as to allow a large flow of water. This does not answer the desired end, and renders the offending person liable to a penalty for wasting water.

Many different forms of water-closet are in use. In all of them the main requisites are that there should be (1) a good flush of water, (2) a rapid removal of the excreta, and (3) no possibility of reflux of gases. The chief varieties of closets are the pan-closet, the valve-closet, and the wash-out closet, but there are endless modifications of these.

Pan-closets are the worst kind, though as yet the most commonly used. The construction is shown in *Fig. 30* (*A*). Below the conical basin there is a metal pan capable of holding a certain amount of water, the lower end of the basin dipping into this water. By means of a pull-up apparatus the contents of the pan can be tilted into a second larger pan or *container*, and the bottom of the container is connected by means of a short pipe with a leaden ᗜ shaped trap, from the side of which the soil-pipe passes out to be carried down to the drain. The only good point about this form of closet is that it requires no over-flow pipe from the basin, as any accidental over-flow of water will escape over the edges of the pan into the container below. In every other respect it is pernicious, and is certain at some time to produce a nuisance, if nothing more. The ᗜ trap and container always arrest a certain amount of foul matter; foul gases accumulate and escape into the house, whenever the closet is used. Occasionally the ᗜ trap becomes corroded by the filth it contains, and then there is free communication with the drain.

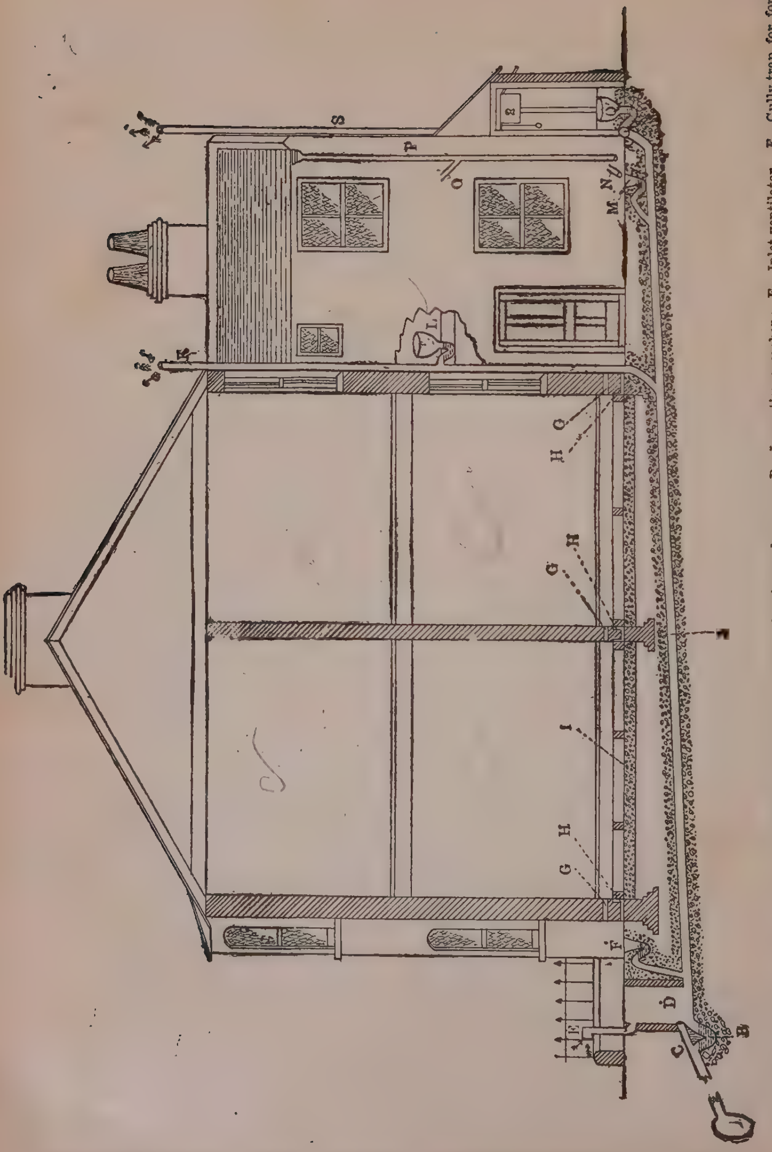
Valve Closets differ from the last in having no container, but only a small box containing a movable water-tight valve, exactly fitting the lower edge of the basin. They are much superior to

the pan-closet, but require an over-flow pipe in order to avoid accidental flooding of the closet. The over-flow pipe should be made with a syphon bend in it, and the flushing of the closet should be so arranged that each time it is performed water enters the overflow pipe. (*See Fig. 30*, B.) The tap below the valve should be in the form of a syphon, as this is not easily fouled. It is preferably made of lead, securely jointed to the soil-pipe and to the pan of the closet. The water remaining in the syphon as a rule prevents sewer gas getting through the valve into the house, and its preventive action is aided by the water contained in the pan. In certain circumstances however, these may be both sucked dry; the soil-pipe should therefore be always ventilated.

Valveless Closets, of which the **Hopper**, the **Wash-out**, and **Wash-down Closets**, are the chief forms, present certain advantages over the valve closet. There is less apparatus to get out of order. They do not require an over-flow pipe, as water can escape freely through the trap of the closet, and no "safe" is required for accidental spillings around the closet. Valveless closets need not be encased by wood-work, thus ensuring freedom from spillings of foul water, and they are more easily used than valve closets for the discharge of bedroom slops, thus obviating the necessity for a special housemaid's sink. For indoor use the valve closet is probably the best when carefully used; but for out-door and servants' closets, some form of valveless closet is less likely to get out of order. (*Fig. 32*, p. 244.)

Where water-closets are required for large collections of people, as in manufactories or schools, the ordinary forms get blocked up, and cause great trouble. Under these circumstances, trough and tumbler-closets have been found very useful.

The **Trough-closet** consists of a series of seats, under which is a water-tight trough sloping towards a common drain, which leads to the sewer by an opening which is closed by a plug. The plug is removed by an attendant once or twice per day, and the contents of the trough allowed to run into the drain; and after washing out



A.—Sewer; *B.*—Intercepting trap; *C.*—Cleaning eye for pipes between chamber and sewer; *D.*—Inspection chamber; *E.*—Inlet ventilator. *F.*—Gully-trap for forecourt; *G.*—Air-bricks for ventilation under floors; *H.*—Damp-proof course; *I.*—Concrete 6" thick over site of house; *J.*—Drain, fall 1 in 24, imbedded in concrete; *K.*—Soil-pipe carried up full size above eaves; *L.*—Upstairs w.c.; *M.*—Gully-trap receiving water from *N* scullery-sink, *O* bath, and *P* rain-water stack-pipe; *S.*—Ventilating pipe at upper end of drain; *T.*—Pipes leading to same.

FIG 29.—SECTION THROUGH A HOUSE FROM FRONT TO BACK SHEWING DRAINAGE ARRANGEMENT.

the trough, as much water is let in as will cover the contents and prevent any smell in the interval. This plan has been found to work admirably in Liverpool, and to compare very favourably with water-closets (often such only in name) in London and other large towns. (Buchanan.)

The Tumbler-closet resembles the last, except in its arrangements for flushing. There is no plug, but at the upper end of the trough a bucket is placed into which water constantly drips, and so arranged that when the bucket is full it tips over, and washes the contents of the trough into the drain. With both these systems it is essential that the soil-drain should be thoroughly ventilated. If this is ensured, they are extremely efficient.

Under valve closets as well as baths, a leaden tray or *safe* is usually placed to catch any accidental overflow of water occurring if the trap of the closet becomes blocked up, or if slops are emptied into the basin. The discharge pipe from the safe should never be connected with the ᗜ trap of a water-closet, or with the soil-pipe, but end (like the waste pipes of sinks and cisterns) in the open air.

The waste-pipe from the housemaid's sink is not uncommonly connected with the trap of the water-closet, thus constituting a source of danger. It should have a special discharge pipe, and be ventilated like the soil-pipe.

The Soil-pipe carries the contents of the water-closets into the drain. Its connexion with the trap of the closet should be perfectly made, and the soil-pipe should pass directly from the closet into the open air. It is much preferable for it *to be carried outside the house* altogether, even though, in order to do this, it has to perform a circuitous course. The soil-pipe should be made of drawn lead without seam. Sheet lead with a soldered vertical joint is not advisable. Any joints in the lead pipe should be of the kind known as "wiped," not a "slip" joint. If an iron pipe is used, perfect joints are more difficult to make than with a lead pipe. If there is any risk of the pipes becoming frozen, they may be covered with Smith's patent felt, or some similar non-conducting material.

The soil-pipe should be throughout its course under observation. It should not be built into a wall, where it might be accidentally pierced by nails, nor within the house, allowing foul gases to escape from weak points in the joints.

The soil-pipe should be four inches in diameter for ordinary-sized houses, and should be continued from its highest point above the roof by a pipe of the same diameter, with its end wide open. This *ventilation of the soil-pipe* is essential, if the house is to be safe from the entry of sewer-gas by the closets, traps alone being unreliable. If no such ventilator is provided, the water discharged out of one closet often draws all the water out of the trap of another, and so leaves the way open for the entry of foul air from the upper part of the unventilated pipe. Where there are two or three water-closets, it is as a rule sufficient to have the uppermost branch of the soil-pipe connected with the ventilating shaft. The junction should be made at the highest point of the syphon of the water-closet. The upper end of the ventilated pipe should be made to open remote from any window. It may terminate in a dilated opening, or have a cowl attached, in order to aspirate the gases contained in the soil-pipe upwards. In the latter case there should be an inlet for fresh air at the other end of the drain, between the house and the water-trap, which we shall see it is desirable to place near the junction of the house drain with the street sewer. This inlet ensures a constant current of fresh air up the ventilating shaft (or *stench pipe*, as it is sometimes called). Some prefer not to have such an inlet, but to allow the stench-pipe to ventilate the street sewers. If every house were provided with a stench-pipe, this would probably be unobjectionable; but under present circumstances it is advisable to disconnect the sewer from the house-system of drainage, so far as possible, by an efficient trap.

Fig. 30a.—Diagram of pan closet, showing its insanitary character.

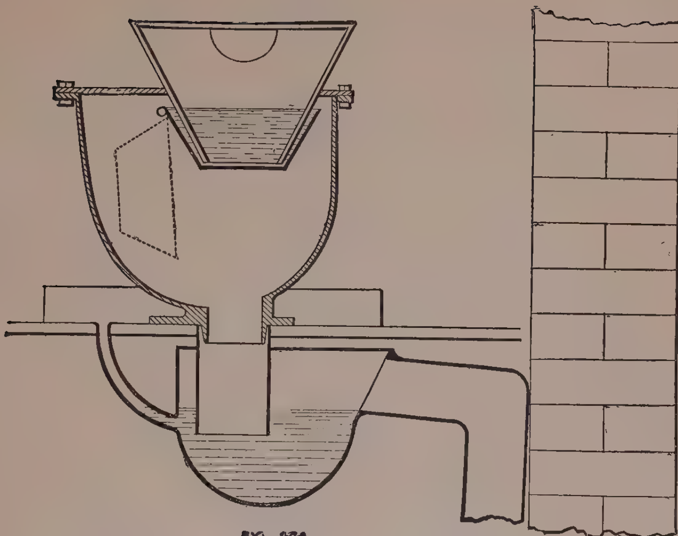


FIG. 80A.

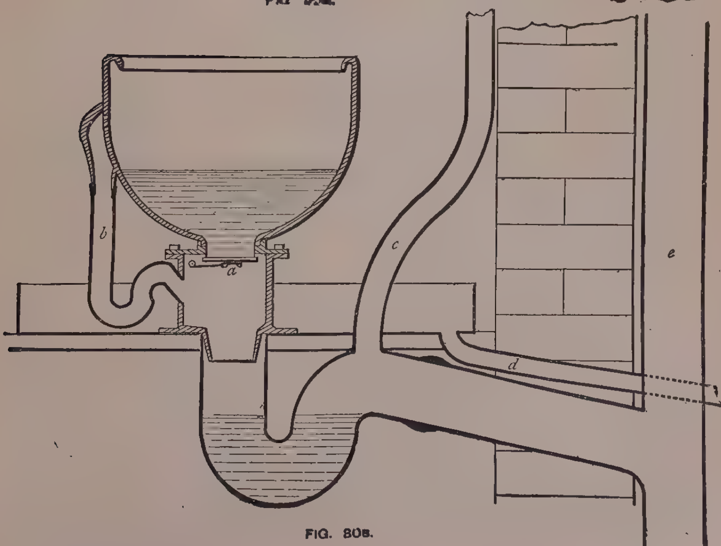


FIG. 80B.

Fig. 30b.—Diagram of sanitary valve-closet. *a.* Valve. *b.* Overflow pipe opening above the syphon trap. *c.* Ventilating pipe for syphon trap, to prevent unsyphoning during discharge of water. This should have been shewn passing through the wall into the external air. *d.* Pipe carried outside from tray to catch accidental spillings. *e.* Ventilating pipe carried up from soil-pipe.

In Mr. Mineard's system of ventilating the house drains, a downward current is induced in the soil-pipe and its continuation upwards to the eaves. This is effected by having a second ventilating shaft in front of the house, continued upwards from the house-side of a Weaver's trap which cuts off connection with the sewer. In the lower part of this shaft is a small chamber, in which a small gas-light is burning. It is found that the heat produced by the combustion of two feet of gas per hour is amply sufficient to produce a constant current of fresh air down the ventilated soil-pipe along the house-drain and up the extraction shaft. This plan has been adopted at Sandringham ; the only objection to it is the expense of the gas, but this is not great, and will probably be reduced.

The House Drain receives the contents of the sink and bathroom pipes, and of the soil-pipe. In old houses, it is often constructed of bricks or porous earthenware, both of which are very objectionable. A pipe is much safer than the old-fashioned quadrilateral drain—well-burnt, hard, and glazed earthenware being the material usually employed.

It is essential that the drain-pipes used should be of good quality. According to competent authorities, a very large proportion of those used do not bear investigation. They should be laid down in straight lines, and without any right-angled junctions. If bends are necessary, bent pipes should be used, and the curve not effected by opening the joints of straight pipes.

The drain-pipes should not be larger than necessary ; as a rule, not more than six inches in diameter, with four-inch branches. The practice of making drains as large as possible instead of as

small as possible, is inexcusable. It is the large drains which become choked, not the small; for, in the latter, the pressure of the water being greater, the rate of movement is also greater; and so all foreign matters are driven along. A fall of at least one in thirty, or four inches in ten feet, should be allowed to a drain, in order to ensure the proper velocity in the transit of the contents, and to prevent the formation of deposits. Where this amount of fall is not obtainable, an automatic flush-tank should be employed for flushing the drain at intervals.

The joints between the pipes must be properly secured; and if cement is used for this purpose, it is important to take care that the cement does not form a hard ridge at the joint. When houses have to be drained from back to front through the basement, the drain-pipes must be bedded in concrete, and have ventilating traps at the back and front of the house. For pipes running under the floors, iron pipes coated with Dr. Angus Smith's patent preservative solution, or treated by Professor Barff's process, have often been used, the joints being made with lead. These present some practical disadvantages, and drains of well-socketed glazed stoneware pipes jointed in Portland cement are the most satisfactory.

Where the drains are laid in concrete, *manholes* should be arranged, so that the drainage system may be accessible, and, if necessary, may be brushed out from end to end without opening up the ground.

The junction of the house-drain with the street-sewer should be oblique, and not at right angles. It should be efficiently trapped, the common flap-trap not being sufficient for this purpose.

Traps are now very properly required for house-drains of all new buildings, under the bye-laws issued by the Local Government Board. Bye-law No. 63 requires that all house-drains shall be trapped from the public sewer or cesspool. Various traps have been devised for this purpose, all being modifications of the syphon, with ventilating openings. *Weaver's ventilating sewer-air*

trap is an excellent contrivance of this kind, being simple in arrangement, and not liable to become blocked. The water in D prevents sewer-gas proceeding towards the house; but a much more effectual preventive is furnished by the opening at E, which can be connected with an upright ventilator, just as is the soil-pipe. If the street-sewer is provided with a ventilating shaft, this is unnecessary. Any foul matter which may have become dissolved in the water D, is immediately diluted with a large volume of fresh air descending through the inlet C.

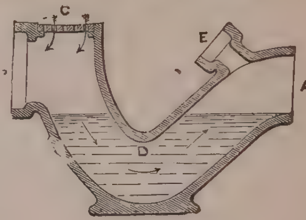
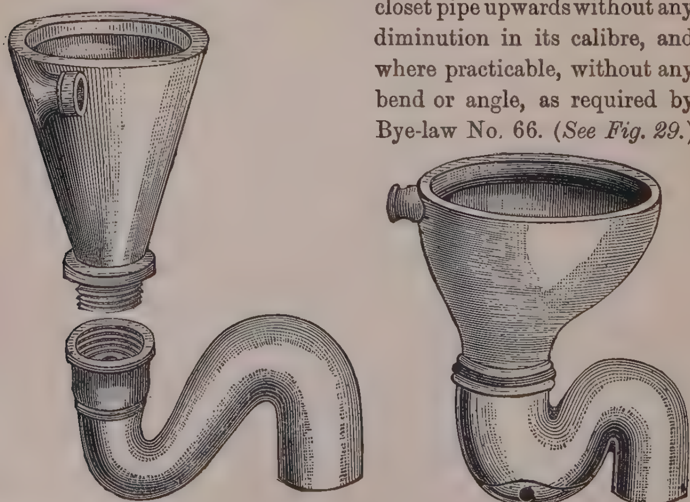


FIG. 31.
WEAVER'S INTERCEPTING TRAP.

Bye-law No. 65 requires the provision of two ventilating openings for the house-drain. One of these should be on the house side of, and as near as possible to, the trap, and is furnished at C in Weaver's trap. The other is provided by carrying the water-closet pipe upwards without any diminution in its calibre, and where practicable, without any bend or angle, as required by Bye-law No. 66. (*See Fig. 29.*)



A. FIG. 32. B.

A. Long Hopper closet, shewing the conical shape of pan, which is very apt to become foul, and the spiral flush of water, which is quite insufficient for cleansing the pan.

B. Short Hopper closet, shewing the best form of pan, with rim flushing arrangement, and back part of pan more vertical than front part, thus diminishing the danger of fouling.

Varieties of Traps.—As traps are commonly the only means used to prevent the warm house drawing sewer air into its interior, their construction is a matter of great importance. There are endless varieties, but they may be classed conveniently under four heads—the syphon, mid-feather, flap-trap, and ball-trap.

The *flap-trap* is merely a hinged valve allowing water to flow only in one direction. It is probably very inefficient for preventing the reflux of sewer-gas. The *ball-trap* is scarcely ever used in drains.

The *syphon* is a useful form of trap, most efficient when its bend is deep, and like the letter U. (*See Figs. 31 and 32.*) It sometimes gets blocked up, and for that reason it is advisable to have the limb nearest the house almost vertical, and the other limb sloped, so as to increase the rapidity of the current through it. It is also well to have means for reaching the syphon and cleaning it out.

The *mid-feather trap* is simply a box of varying shape, with the entry at one side and the discharge pipe at the other, and one or more partitions reaching down between these. The D trap, the common bell-trap, and the dipstone-trap, belonging to this division, and none of them is very efficient. The presence of partitions tends to produce obstruction of solid matters, and they sooner or later give rise to nuisance.

The D trap and bell-trap are chiefly employed in yards and sinks to receive rain-water and waste-water from kitchens and baths. The cover of the bell-trap is removable and then the drain becomes untrapped. Very frequently the cover is broken or lost. It is impossible to make a thoroughly sound junction between the D trap in a yard and the drain. The best form of surface trap is the gully

(*Fig. 26*), and the best form of intercepting trap for the underground drain, is the trap shewn in Fig. 31, or some modification of this.

Efficiency of Traps.—Eassie has said "honestly speaking, traps are dangerous articles to deal with; they should be treated merely as auxiliaries to a good drainage system." There are various causes which lead one to look on traps as *traps* in another sense, giving a false sense of security, when none exists.

(1) Very commonly the trap is badly laid to begin with.

(2) It may be emptied by evaporation, or become clogged if water is not frequently sent through it.

(3) The flushing of one trap may empty others, when two or more traps are connected with the same line of pipe without any ventilation of the pipe.

(4) The water of the trap may become impregnated with sewer effluvia, and then these escape on the house side. Dr. Fergus, of Glasgow, made some interesting experiments with a syphon tube containing water, and found that ammonia passed through the water in from fifteen to thirty minutes, sulphuretted hydrogen in three to four hours, sulphurous acid in an hour, carbonic acid in three hours. When a ventilating pipe was fixed at the highest point of the syphon, similar results were obtained, only the reaction was a little slower in appearing.

(5) When the pipe is only two or three inches wide, and "runs full," especially if the descent is a rapid one, the water may be sucked out of the trap; to avoid this, the pipe must be large enough to prevent its running full, or the trap must be larger than the rest of the pipe.

(6) The pressure of the sewer-gas may force it through the water of the trap. When a sewer suddenly becomes charged with a large amount of water, as after a heavy fall of rain, or when hot water is poured down a drain, great pressure is exerted tending to drive sewer-gases towards the house. At the same time, the higher temperature of the house commonly brings to bear an aspirating force, which greatly aids the external pressure

of sewer-gas. Few traps possess a resisting power exceeding that of a column of water $1\frac{1}{2}$ inches deep; and most of them, as the common bell-trap, have a resisting power of only a quarter-inch.

It may be gathered from these statements that a trap will keep out a stench which does not want to come in, but that its efficiency ceases when most urgently required. These objections do not hold to the same extent against ventilated traps.

The Examination of Drains ought to be undertaken in every house, in order to ensure that they are arranged according to sanitary requirements. It will be convenient to recapitulate the main points to be ascertained in such an examination.

1. The overflow pipe from the cistern should open into the outer air.

2. The water-closet should not be supplied from the same cistern as that providing drinking-water.

3. All waste and overflow pipes from the bath-room should open on to a grating in the yard, over a trapped junction with the drain.

4. All sink-pipes should similarly open on to a grating in the yard.

5. The soil-pipe should be continued upwards to the roof by a pipe of the same diameter, which is open at its upper extremity.

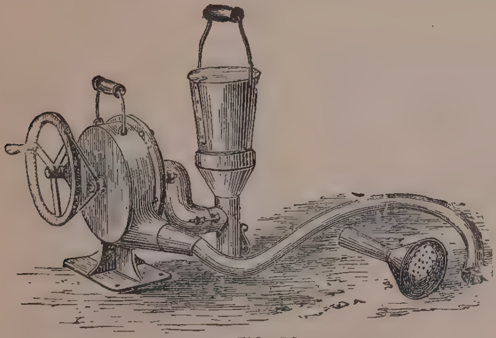


FIG. 33
THE PATENT ASPHYXIATOR.

6. The rain-water stack-pipe must not be used for ventilating the soil-pipe.

7. The house-drain should be trapped by a ventilating trap, between the house and the main sewer.

Occasionally leakages occur in the soil-pipe or some other part of the drainage

Such defective drains may be easily detected by Watts' Patent Asphyxiator (*Fig. 34*), which is really a more efficient means for applying the smoke test to drains. Some sulphur or smoke paper is put into the combustion chamber and ignited; if the nozzle at the end of the flexible tube is then inserted into the drain or soil-pipe, the rotation of the fan will force the fumes a long distance. All outlets or ventilating pipes must be carefully stopped during the operation, and the place where the smoke or sulphur is smelt, will then indicate any leaky point. The same apparatus may be used for disinfecting purposes.

Another test commonly applied, is to put about a table-spoonful of strong oil of peppermint, mixed with hot water, down the highest water-closet in the house. If this is smelt by another person in the lower closets, it indicates defective traps.

The only absolutely trustworthy test for underground drains is to plug the end nearest the sewer, and then attempt to fill the drains with water. If the level of the water does not fall after the drain has been filled, the drain may be regarded as sound.

Rats are an important indication of defective drains. The presence of rats in a house should always lead to a thorough investigation of its drains.

CHAPTER XXV.—CESSPOOLS AND MAIN SEWERS.

Use of Terms Drain and Sewer.—Cesspools.—Construction of Sewers.—The Separate System for Rain Water.—Ventilation of Sewers.—Flushing of Sewers.—The Outfall.

The terms **Sewer and Drain** are used somewhat confusedly. By some the name of "drain" is confined to the channels in which surface or subsoil water is conveyed, and "sewer" to those containing foul water from the house. It is preferable, however, to employ the term *drain* to indicate the pipes bringing the sewage from the house into the street-sewer, and the canals by which the subsoil is drained; while the term *sewer* is confined to the trunk canals into which the house drains empty their contents.

Where the water-carriage system of sewage is adopted, involving

the use of water-closets as described in the last chapter, the sewage may be carried from the house either into cesspools or into the main sewer. The former plan is strongly to be deprecated, as the moist condition of the excreta renders them very prone to decompose and produce a nuisance.

Cesspools are only admissible in isolated country-houses supplied with water-closets. They should always be situated a considerable distance from the house, and should be emptied at regular intervals. The sewage may often be advantageously put on the land at once. The emptying of a cesspool always produces a temporary nuisance, unless it is well removed from the house and in the centre of a field.

The construction of the cesspool requires careful attention. Its walls should be of brickwork set in cement, lined inside with cement, and surrounded by clay puddle. The bottom should have a fall towards one end, where a pump can be fixed, to remove the more liquid contents. The depth of the cesspool should not exceed 7 feet, and it is a safe rule to make it in every case as small as possible. The drain emptying into the cesspool should be trapped and ventilated, near its junction with the cesspool; and the cesspool itself should be ventilated.

In connection with many of the older London houses, cesspools still exist, sometimes under the basement or near the house, and built with walls which allow soakage in every direction. The surrounding soil becomes contaminated for a considerable distance, the water in any neighbouring well is tainted, or leaky water-pipes receive the soakage. In towns where a central system of sewage exists, any existing cesspool should be cleansed out and then closed, and a direct connection made between the drain and the street-sewer.

Sewers are built of brick laid on a bed of concrete to prevent sinking of any part, the parts being most solidly put together. Their cross-section should be an egg-shaped oval with the small end downwards, it being found that this ensures the most rapid current. They should be laid in as straight a line as possible, and with an

even fall of from 1 in 244 to 1 in 784, so as to ensure a flow of at least two feet per second. Where a town is very flat, and a proper fall of sewer impossible, it is necessary to have locks at given points, which on being suddenly released flush the next section. In such cases the necessity of thorough ventilation of every portion of the sewer is specially great. Tributary sewers and house drains should join at oblique angles, in the direction of the main flow. At the junction with house drains, manholes should be placed in order that any obstruction may be removed; and the house-drain should be trapped near its junction with the sewer.

Inasmuch as the sewers have commonly to carry away the rain-water in addition to the waste matter from houses, their size must be regulated accordingly. The rainfall being very various, the sewers may occasionally become choked when it is excessive, while at another time they are imperfectly flushed. The storm-waters are got rid of, in the case of London, by having special openings into the Thames.

There are certain disadvantages in allowing the rainfall to enter the sewers. The sewage is thus diluted and rendered less useful for irrigation; larger sewers are required; and there is occasionally difficulty with the storm-water, which by overfilling the sewers may force sewer-gases up into dwelling-houses. The consideration of these facts has led in some cases to the adoption of **The Separate System**, by which the rain is carried in special conduits to the nearest river. The objections to this plan are that it necessitates a double system of drainage, and does not allow of the useful scouring effect of rain on sewers. Where it is feasible, however, it is certainly the best in principle, and is adopted in many new schemes of drainage. In such cases the old brick drains are used for carrying off rain-water, while new *pipe-sewers* are employed for carrying the sewage. Such pipe sewers can be quickly laid, and of any degree of curve required; they are not so liable to become fouled as brick-sewers, and on account of the decreased dilution of the sewage can be made smaller than brick-sewers. Their only

disadvantage is that they do not dry the subsoil, but this is unnecessary if the double system is adopted.

Sewers being closed conduits containing decomposing sewage, it is highly desirable that the gases resulting from decomposition should be freely diluted. Such gases always tend to diffuse, and if the only openings into a sewer be from the various houses in its track, they will receive its gases spite of all the traps devised. **Ventilation of the sewer** is, therefore, essential. This may be accomplished by gratings opening directly into the streets, when the latter are not too narrow. But in narrow streets, the stench is often so great that the inhabitants stop them up, and so the smell from other ventilators is intensified. There should be one ventilator for every 100 yards of a main sewer, or 18 to a mile (Rawlinson). When this proportion of ventilating gratings is allowed, generally no nuisance arises from them. Sewer gases as a rule are *only dangerous when concentrated.* Free dilution oxidises the organic matter associated with the active germs of disease, and as the latter require a soil in which to grow, oxidation of the soil obviates the danger of their development. Charcoal is occasionally used at the sides of ventilating gratings, or in manholes, to deodorise the sewer-gas. One cubic inch of beech-wood charcoal contains pores equal to an area of 100 superficial feet (Liebig). It absorbs 8 times its bulk of carbonic acid. Not only does it deodorise, but to some extent oxidises the organic matter, changing it into nitrites and nitrates. It, however, requires frequent changing, and often gets clogged with dust; and it is much better to trust to multiplication of ventilators, than to the deodorising of sewer-gases by any means.

Ventilating shafts may be erected at the highest point of the sewage system of a town, and again at the point of discharge. It has also been proposed to erect shafts at intermediate points, and by some to make the lamp-posts useful for this purpose. When sewers are laid with too deep a gradient, they act as chimneys, the gases mounting to the higher part of the town, and frustrating

any attempts at ventilation on lower levels. This explains why, in a few cases, typhoid fever has increased after the introduction of a general sewage system (*see page 267*).

Artificial ventilation of sewers is, as a rule, not advisable. Any attempt to drive the air along in a sewer (plenum system) will force the traps of houses, while attempts to exhaust it (vacuum system) only affect a very short length of sewer.

Flushing of Sewers is required at intervals, in order to remove any deposits of solid matter. Such deposits, with occasional choking, are due to the sewer being badly constructed, or having sunk in its bed, or presenting sharp curves in its interior, or the flow of water through it being deficient. Flushing is effected by damming back the water, and then allowing a sudden rush, which is generally effectual in removing the ill-smelling obstruction.

Spite of free ventilation and regular flushing, sewers will occasionally emit foul odours. The use of charcoal will diminish this nuisance, but is obviously only a palliative. Very commonly the fault is in the construction of the sewer. If this is old and leaky, it practically constitutes an elongated cesspool, and the sooner it is replaced by a perfectly built sewer the better.

Whenever there is stagnation, a foul odour is certain to be emitted. The cardinal rule with regard to sewage is to keep it in rapid onward motion, until it has passed the outlet of the sewer. *The introduction into a sewer of hot water* is to be greatly deprecated. It facilitates putrefactive changes, and as a comparatively high temperature is necessary for the development of the microscopic organisms to which specific fevers are probably due, it may also aid in propagating these. Dr. A. Carpenter has suggested a close connection between washing days and the origin of diphtheria.

The Outfall of a sewer requires to be large and perfectly free in order that the progress of the sewage may not be impeded. When the sewage is discharged into the sea above the low water level, it becomes backed up in the main sewers when the tide is high. This backward pressure has occasionally been so great as to

force the sewage even into the cellars of houses. The same condition of things has occurred when the outfall is into a river below the water line, or into a tank out of which the sewage has to be pumped. In all these cases the ventilation of the sewers requires to be perfect, and great precautions taken to prevent obstruction of the outflow; otherwise the mortality from typhoid fever does not decrease, according to the general rule, after the establishment of a water system of sewage.*

CHAPTER XXVI.

THE DISPOSAL OF SEWAGE.

Discharge of Sewers into Streams.—Discharge into the Sea.—Treatment by Subsidence.—Precipitation by Chemical Means.—Filtration.—Intermittent Downward Filtration.—Irrigation.—Objections to Sewage Farms.—Dust and Dustbins.

The water-carriage system of sewage is as Dr. Parkes puts it, "the cleanest, the readiest, the quickest, and in many cases the most inexpensive method." But when the sewage is conveyed to the outfall of the sewer, its ultimate disposal is still one of the most difficult problems of the present day. Various plans have been adopted, of which the following are the chief:—

1. Discharge into running water.
2. Discharge into the sea.
3. Separation of solid and liquid parts $\left\{\begin{array}{l}\text{By settlement.}\\ \text{By precipitation.}\end{array}\right.$
4. Filtration through various media.
5. Irrigation.

Discharge at once into Running Water was formerly the favourite plan, as it was certainly the most convenient. The sewage was turned into the nearest watercourse, regardless of the fact that this might have to supply the drinking water of people at a lower point of the stream; as well as of the facts that the mouth of the river tended to become obstructed by sewage mud, that valuable stocks of fish were destroyed, and that the river which had

* Problems as to the Flow in Sewers are considered in further detail on page 434.

practically become a sewer was a source of annoyance and danger to all on it or near it. By the Rivers Pollutions Act of 1876, any future sewage works are forbidden in which the sewage is discharged into a river or stream without previous purification, though the exact amount of purification compulsory is still doubtful.

The sewage entering rivers undergoes considerable purification by subsidence, by oxidation, and by the influence of water plants. These however cannot be depended on, especially in regard to the most important class of impurities, namely, those which cause typhoid fever and other diseases.

Discharge into the Sea is resorted to in seaboard towns. The outlet pipe should, if possible, be always under water. If not, special care must be taken to prevent the wind blowing up the sewers. There should be a trap at the mouth of the outlet opening outwards, to partially prevent the rise of the tide banking up the sewage. If the sewage cannot be got out well to sea, it may cause a nuisance, and require to be purified before discharge.

In both these methods, there is a great waste of manure. The annual value of the sewage of London alone has been estimated at more than one million sterling.

For a single house or small village, the sewage may be stored in **a tank, with an overflow-pipe**, out of which the liquid parts escape, and are used to irrigate the land, while the solid parts are removed at intervals.

A similar subsidence system has been employed on a larger scale, the liquid parts being either turned into the stream or over the land, while the solid parts are mixed with street sweepings, and sold as manure.

If the liquid parts in any such system as this are turned into a stream, they are as offensive as the entire sewage, and the legal prohibition to discharging sewage into streams applies to them also.

The **precipitation of the solid parts** of the sewage is rendered much more perfect by the use of **chemical agents**, and at the same time the dissolved matters are to some extent removed.

(1) *Lime salts* are used as precipitants at Bradford and other places; cream of lime is usually employed, the precipitate being sold as manure or made into bricks. This plan seems to be a failure, both in respect of the purification of the water, and the value of the manure. In *Blyth's process*, a mixture of phosphates of magnesia and lime is used, but these only cause precipitation when the water contains an excess of ammonia, and the whole process is costly and not very efficient.

In *Whitbread's process*, the precipitant is a mixture of mono- and di-calcic phosphate with a little lime; the precipitation is rapid and complete, and the resulting manure apparently valuable.

(2) *Salts of Alumina* are also employed. *Bird's process* consists in the addition of crude aluminium sulphate, and subsequent filtration through coke. The resulting liquid is not sufficiently purified for admission into a river, without causing a nuisance. In *Anderson's process*, which produces a much more perfect result, the same salt is used, and the liquid is subsequently passed through a filtering bed.

(3) *Carbon* has been used, as vegetable charcoal, peat, lignite, etc. On a small scale it answers well, and produces a valuable manure.

(4) *Iron Salts.*—In *Holden's process* a mixture of iron sulphate, lime, coal-dust, and clay is added, but the liquid remaining does not contain a diminished amount of organic matter in solution.

These are only a few of many precipitation processes tried at various places. According to Dr. Parkes, the best precipitants appear to be the aluminous salts; the crude sulphate of alumina (Anderson's process); Lenk's patent solution; Sillar's A B C process, consisting of alum, charcoal, blood, and clay; and Forbes' acid solution of phosphate of alumina.

The precipitated solids are known as sludge. They are usually dried, and then sold as manures. The profit from them is never large, and in many cases they are a drug on the market.

Instead of making manures, the sale of which has often to be

subsidised, General Scott has proposed the addition of lime and clay to the sludge, and then burning to make cement. It is doubtful whether the sewer water resulting from any of these precipitation processes is in a fit condition to be discharged into streams. It still contains in all cases some organic matter, potash, ammonia, and phosphoric acid.

Filtration of the sewage matter has been accomplished in various ways. In *Weare's process*, it is filtered through *carbon*, but this has not been very successful. *Upward filtration* has also been tried with unsatisfactory results.

Intermittent downward filtration through a considerable depth of soil has been found by the Rivers Pollution Commissioners to be attended with very good results. A porous soil is chosen, and the purified water is received in drains under it. The organic matter is to a large extent oxidised into carbonic acid, water, and nitric acid. Dr. Frankland's experiments shew that upward filtration through the same media does not purify. Downward intermittent filtration has been carried out on a large scale at Merthyr Tydvil, cabbages being planted on the surface of the filtering bed, thus helping to get rid of the organic matter.

Irrigation is the only process which at the same time purifies the sewage efficiently, is not detrimental to the health of neighbouring people, and may possibly produce a small profit. The sewer water is allowed to flow at intervals over the land, different fields being irrigated in rotation. Immense crops of grass are obtained, though the grass tends to be coarse and rank.

The soil to be irrigated should have a gentle slope, and the water be conveyed by subsoil drains about 5 or 6 feet deep into the nearest water-course. The sewage should be delivered in as fresh condition as possible, and should be freed from its coarser portions by settlement or precipitation. The amount of land required is about 1 acre for the sewage of 100 persons. The irrigation must be on the intermittent plan, in order that the soil may undergo aeration; as it is only in this way that the best purifying results

can be obtained. The sewage farm should be well drained, and not laid out on the saturation principle. If the farm is converted into a marsh, marsh diseases, such as Ague, may result, but this is not owing to the water being sewage water.

Various objections have been urged against sewage farms.

(1) The nuisance arising from decomposition of the sewage has been urged. On the farm itself with good arrangements, this is nót perceived, but the suspended matters may be troublesome. They may be utilised for making cement or solid manure.

(2) It is said that rinderpest, and foot and mouth disease, are more common on these farms than elsewhere; but this is not the case.

(3) The possibility of the diffusion of typhoid fever along with the irrigation has been suggested, but there is no evidence that this occurs. In regard to cholera, a disease having similar modes of progression with typhoid fever, there are important negative facts. At Milan where the sewage is removed by irrigation, during three epidemics of cholera, no case occurred on the irrigated meadows; and there is similar evidence in the case of Edinburgh.

(4) The possibility of the ova of parasitic worms being spread in irrigation farms has also been mentioned. At Edinburgh however after many years' experience of the system, it has been impossible to trace a case to this source. The examination of mud and slime from the irrigated parts failed to discover any ova; cows fed for a year or two on such a farm were examined after death, without the discovery in any case of cysts; and as Dr. Cobbold pointed out, there was on these farms a remarkable absence of the molluscs and insects which often form intermediate hosts to the larvæ of parasites.

When the wet system of sewage is adopted, the removal of **Dust** involves a special arrangement. It includes chiefly ashes and cinders, but commonly the dust-bin is the receptacle also of all kinds of vegetable and animal refuse. The more frequently the dust is removed, the less likely it is to become a nuisance.

The *dust-bin* should not be placed against the wall of the house; the model bye-laws name six feet as the least distance. It should be protected from the rain, as moisture favours decomposition; and should be of a small size. It is still better to have no dust-bin at all, but a pail or box, in which the dust is placed. This can easily be removed by the dust-man, without causing any dirt, and it ensures that no dust is allowed to collect about the premises.

In places where brick-making is going on, dust is valuable, and the scavenging is consequently well done. But in places where (as in London at present) the dust is valueless, it is difficult to secure proper attention to this matter, especially as it is commonly undertaken on contract by private individuals.

CHAPTER XXVII.

THE DISPOSAL OF EXCRETA BY DRY METHODS.

The Cesspool System.—The Pneumatic System.—The Intercepting System.—The Pail System.—The Goux System.—Disposal of Contents of Pails.—Dry-earth Closets.—Middens.—Disposal of Slops.—Relative Merits of Dry and Wet Methods.—Influence of the Water-carriage System on General Health.

It will be remembered that the refuse to be removed from a house consists of fouled water, which is at least equal in quantity to the water-supply of the house; the excreta of the inhabitants; and "dust," which contains, besides ashes, considerable kitchen refuse, consisting of both vegetable and animal matters.

In dry methods of removing refuse, the dust is commonly added to the excreta, and the two removed together. But the foul water, and to a large extent the urine, remain to be dealt with, and require special drains for their removal. Thus in large towns, whether dry or wet methods of removing sewage are adopted, drains for the removal of foul-water and rain-water will be required, and it is found that they are open to the same objections as if they contained the solid excreta.

We shall describe briefly 1. The cesspool system.
2. The pail system.
3. The dry-earth system.
4. The midden or privy system.

The Cesspool System has been already named (*page 249*), but only to be condemned. Formerly it was not at all uncommon for each house in London and elsewhere to be provided with a hole or cesspool, known as a dumbwell, into which all the excreta and slop-water were conveyed. These were often placed under the basement of the house, and instead of being made impervious to moisture, were so rudely constructed as to allow soakage in all directions. In fact in many cases they were made with this distinct object.

The greatest improvement in cesspools is the rendering them impervious by lining them with cement. They may then be drained so as to leave the solid excreta more or less dry; or be made to retain both the liquid and solid excreta. The latter plan is adopted in Paris and many other continental towns; but the former plan is preferable from a sanitary stand-point, as it renders the contents of the cesspool much less offensive, and diminishes the danger of contamination of the subsoil by soakage or overflow. It is evident, however, that if the cesspool is drained into a sewer, the contents of the latter become as dangerous as if the whole of the excreta were emptied into it, and in fact often more so, owing to the liquids from the cesspool being stale and putrefied.

When cesspools situated in the basements of houses are large, as in Paris, they require to be furnished with ventilating shafts, reaching above the eaves. In the absence of such ventilation, the men who empty the cesspools are in danger of being suffocated. They are also very liable to an inflammation of the eyes (ophthalmia). The cesspool is usually emptied by a pump or hose leading into a partially exhausted barrel. The soil-pipes and the sink-pipes leading to the cesspool require to be trapped by means of a syphon at their upper and lower ends. The emptying by means of a closed barrel is a great improvement on the old plan of

emptying by hand and bucket, but still produces a considerable nuisance.

A modification of the cesspool system, called the **Pneumatic System** has been proposed by Captain Lierneur. In it the cesspool is not placed under the house or the courtyard of the house, but under the street at the angle of junction of several streets. It is made of cast-iron and air-tight, and is connected with all the houses of several streets by iron-pipes. By means of a powerful air-pump worked by steam, the cesspool is emptied into barrels in which it is sent directly to farms, and the barrels being placed on ploughs of peculiar construction, the manure is discharged from the bung-hole of each barrel and covered over with earth in the progress of the plough. The pipes tend in this and similar systems to get clogged with fæcal matter, and large quantities of water are required to keep them clean, so that the system merges into that of the use of water-closets, but without the thoroughness of the latter.

Cesspools have been almost improved out of existence in some continental towns, by the introduction of movable cesspools,—*fosses mobiles*,—to which would correspond strictly the tubs and pails used in some of our large towns. Such movable receptacles may be still further improved by the adoption of *separators*, by which the liquid parts are allowed to escape into the sewer, while the solid parts remain comparatively innocuous. In **Cheshire's intercepting tank** this plan is adopted.

In cases where slop water is emptied into cesspools, as well as the excreta, more rapid decomposition will occur, and consequently the danger is increased. On the other hand, if the slop water and the urine be emptied into the sewer, the contents of the latter become as offensive and dangerous as if the solid excreta were likewise added; and with the urine one of the most valuable parts of the excreta for commercial purposes is lost.

The Pail System implies in reality the use of a movable cesspool. The pail may be used alone, or may contain ashes and house

refuse, or some deodorant. Where the pail is used without any admixture of foreign matter, it should be emptied daily, and care should be taken that the pails for different houses are not exchanged. This plan has been practised for thousands of years in China, and has been adopted in the Department of *Alpes Maritimes*, where the excreta are used for growing vegetables, and especially scented flowers, such as roses and violets.

In the **Goux System** the tubs are lined with a composition containing clay and furnished at the lowest part with some absorbent material such as chaff, straw, or hay, which serves to absorb the urine and retard putrefaction. This is, when well managed, somewhat less offensive than the ordinary pail system.

The pails may be supplied with a deodorant, such as sulphate of iron, as at Birmingham, Leeds, etc.; they may be packed with absorbent material, as in the Goux system (Halifax); the ashes and house-refuse may be deposited in the same pail (Edinburgh, Nottingham); or coal ashes may be scattered over the excreta (Manchester, Salford).

In all large towns it becomes a very serious difficulty to know how to dispose of the pail contents which have been collected. By Fryer's patent "*destructor*" and "*carboniser*," this question is largely solved. The ashes collected in ash-tubs are acted on by the "*destructor*," which pulverises all the more bulky town refuse. The slag produced is ground, mixed with lime, and sold as mortar. The heated products of combustion pass over fresh portions of material and prepare it for burning, thus preventing any loss of heat.

Street sweepings, including vegetable and animal refuse, are reduced to charcoal by a furnace called a "carboniser," the fuel required for this purpose being furnished, in the first instance, by a portion of the sifted cinders from the ash-tubs.

By means of *Firman's Drying Apparatus* the contents of the pails can be reduced to the consistence of guano and used as such.

The Dry-earth System is an important modification of the pail

system. In it dry earth or some other material is added to the excreta, thus converting them immediately into an inodorous mass. Probably the best contrivance for thus deodorising the excreta, as soon as they fall into the receptacle, is **Moule's Earth-Closet.**

It is found that 1½ lbs. of dry earth, completely deodorise the closet each time it is used. Loamy earth is the most valuable material; a mixture of peat and earth or ashes is very good; sand, gravel, and chalk are practically useless. It is necessary that the earth should be very dry, and that it should be finely sifted. If the earth is damp, decomposition of the excreta speedily occurs. Sitting and rising works a hopper which scatters a supply of earth.

Charcoal and saw-dust have also been used in connection with this closet, or the next, and with good results. Charcoal has been obtained cheaply for the purpose from street sweepings, and from seaweed. Mr. Stanford has patented a process, in which he absorbs the excreta with charcoal, and afterwards dries and carbonises the mixture, thus producing a constantly increasing amount of charcoal, which may be used for various purposes.

The **Moser Dry Closet** is similar to the last in principle, and its mechanism being automatic and simple, it is not very liable to get out of order. A sufficiency of earth to last for some time is placed in a hopper behind the seat of the closet, whence it falls on to a valve capable of holding exactly 1½ lbs. The valve is so arranged that when the seat is vacated or a handle moved, the contents of the valve are upset into the receptacle below.

The dry earth system is much more expensive than the pail system, and although applicable to villages and isolated houses, is quite unsuited to large towns, owing to the practical difficulties connected with the procuring and storing of dry earth. The dry earth closet requires frequent attention, in addition to not being so convenient as the pail closet.

It is doubtful also whether the compost produced is disinfected, as well as deodorised. It is quite possible that if derived from a

typhoid fever patient, for instance, it would regain its contagious character when moistened.

The value of the manure derived from earth-closets is not so great as that from pail-closets. Theoretically the manure value of the excreta of each individual should be from eight to ten shillings per annum. This is, however, by no means realised in the market, though the excreta are most valuable when unmixed with foreign matters.

The advantages of the earth-closet as compared with the water-closet have been thus summarised by Dr. Buchanan. "It is cheaper in the original cost, it is not injured by frost, it is not damaged by improper substances driven down it, and it very greatly diminishes the quantity of water required by each household."

The Privy or Midden System, involving the use of a fixed receptacle, is still prevalent in many towns as well as in innumerable villages. In its worst form, the receptacle consists of a pit with sides of porous materials, allowing percolation of filth in every direction; and in this pit the excreta of whole households are allowed to collect for months, or even years. It has been improved by providing a cover to keep out the rain, and thus retard decomposition; still more by providing a drain for the excess of liquid; and by making the sides and bottom of the pit impervious to moisture. The addition of dry ashes to the excreta tends still further to prevent any smell; and the greatest improvement of all, consists in raising the receptacle above the ground level, and providing for easy cleaning from the back. The raising of the receptacle involves a diminution in its size, and so prevents the retention near a house for a long time of putrefying matters. The privy should not be situated within six feet of a house, and abundant means should be provided for its ventilation near the top.

Even when carefully supervised, middens are almost certain to be productive of evil. They possess two great disadvantages as compared with pails or dry closets. (1) The time between collections of excreta by the scavengers is much longer; and (2) the receptacle

for the refuse is part of the structure of the building, and cannot easily be renewed when it has become saturated with excreta.

The use of pails or dry-earth closets is a great improvement on the old middens, but even these compare very unfavourably with water-closets in two respects. (1) The excreta require to be retained about the house for a longer or shorter period, whereas with an efficient water-carriage system, they are at once projected into the sewer. (2) In removing the excreta, the weight of the receptacle has to be added to that of the excreta, while in the water-carriage system, the water serves as the means of transport.

In villages and isolated houses, where no drains are provided for waste water, and the dry system of closets is adopted, the **disposal of waste water** requires special provision. Very commonly the slops are thrown out of the door, and soak into the ground about the house; or worse still they are thrown into the dust-bin, to set up decomposition there. They should be carried by means of a waste-pipe into a special water-tight dumbwell, remote from the house, whence they can be pumped into a field, or carried away by special conduits.

Relative Merits of Dry and Wet Methods.—This has been the subject of much controversy, but no answer can be given in exclusive favour of either plan. Each is the best under different circumstances; the dry method being chiefly suitable for villages, and temporary collections of people, as in camps; and the wet method for large towns.

Under certain conditions dry methods may be preferable, even for large towns. Thus (1) if a sufficient *fall* for the sewers cannot be obtained; or (2) if the *water-supply be scanty;* or (3) if the climate be such as to *freeze the water* for some months in the year. And even when these conditions do not exist, many authorities favour dry methods of removing sewage, on account of (4) the *greater value of the manure* thus obtained.

The **objections to the water-carriage system** are numerous, but most of them are really due to its not being carried out in

an efficient manner. What is required to remedy such defects, is not an abandonment of the sewer system, but a greater degree of perfection of the engineering and workmanship concerned in carrying it out. When sewers are properly laid; when they, as well as house-drains, are freely ventilated; when house-drains are efficiently trapped and ventilated near their junction with the sewer; when the supply of water to the drains is abundant, and the outflow from the sewer is unimpeded—many of the objections disappear.

These objections are that—(1) the sewers, as underground channels, transfer effluvia and the germs of disease from one place to another; (2) pipes become disjointed owing to being badly laid, and the ground is contaminated; and (3) the water supply is in constant danger of receiving impurities from the sewage.

The only objections which are of any force, are (4) that water-closets require a large amount of water, and the sewage obtained is greatly diluted, and consequently diminished in value; while (5) the disposal of such an amount of water, in the case of a large inland town, is a problem of the utmost difficulty.

In view of these last difficulties, in the case of such towns as Birmingham, it is probable that a system of dry-earth closets, with separate sewers for waste water, is preferable.

There are many **objections to the dry methods** of removing excreta. (1) Whatever dry method be adopted, the excreta are retained for some time in or about the house, instead of being immediately removed.

(2) Although the initial outlay in closets and sewers is less than in the wet method, there is the constantly recurring expense of removing the excreta, as well as of cleansing the pails, etc.

(3) In the dry-earth closets, the dry earth or other material added, involves some expense.

(4) Whatever dry method be adopted, sewers are always required to carry off the foul water, as well as trade products, and a certain proportion at least of the urine. It is impossible to

supply sufficient dry earth to absorb all the urine and slops of the population.

Thus, as the Indian Army Sanitary Commission said, speaking of barracks, "to have two systems of cleansing stations—a foul-water system, and a dry-earth system—would simply be paying double where one payment would answer; or, if all the excreta, solid and liquid, are to be carried away, this must be done at a cost ten times greater than that which would be necessary, if all the excreta were removed by drains."

With some of the dry methods, as where middens or cesspits are drained into the sewers, the sewer-water is fouler from being staler, than in towns supplied with water-closets. When a midden or cesspool is drained, the principle of conservation, which distinguishes the dry methods from the wet, is practically abandoned; and not only so, but the solid matters still remain to be disposed of, by a tedious process, while the addition of these to the sewer-water does not render it practically any more offensive or dangerous than before.

(5) The dry systems, involving the retention of excreta about the house, tend to poison the atmosphere, and produce various diseases. In all towns where the refuse matters are not removed immediately, there is a high mortality, and especially among children.

On the other hand, the introduction of the water-carriage system into large towns, with the abolition of midden-heaps and cesspools, has been followed in nearly every case by a diminution in the death-rate, and generally a considerable diminution in that from epidemic diseases, especially cholera and typhoid fever. As regards cholera, towns which had mortalities of from 18 to 26 per 1000 during the epidemics of 1848-49, either entirely escaped after the introduction of the water-carriage system of sewage, or had only a mortality of 1 to 2 per 1000, during subsequent epidemics. As regards typhoid fever, like results were obtained. In one place the mortality diminished 75 per cent., and in 10

others from 33 to 50 per cent., and in some others somewhat less. The average reduction of the number of deaths from typhoid in 21 out of the 24 towns investigated by Dr. Buchanan (9th report of the Medical Officer to the Privy Council), was 45·4 per cent. In the other three cases there was an increase in the prevalence of typhoid fever. In these, however, it was found that the outlet for the sewage was not free, so that it became banked up in the sewers, and there was not free ventilation of the sewers. That this was so, was abundantly proved in the case of Worthing, by the fact that the fever attacked almost exclusively the better-class houses on a high level, where the water-closets were inside the houses; and that it disappeared when ventilation of the sewers at these parts was secured.

CHAPTER XXVIII.

THE MATERIALS USED IN THE CONSTRUCTION OF HOUSE WALLS AND ROOFS.

Bricks.—Their Conductivity and Porosity.—Mortar.—Varieties of Stone.—Slates and Tiles.—Flint-work.—Concrete.—Terra-Cotta.—Lead and Zinc.—Thatch.—Plaster.

Walls of houses are constructed of brickwork, stonework, flint and boulder work, concrete, half-timber, or terra-cotta. Half-timber walls are formed of a combination of brickwork and timber.

Bricks are generally of a uniform size, of 9 inches in length by $4\frac{1}{2}$ in width and 3 inches in thickness. Those bricks which are heaviest and hardest are generally the most durable, bricks of good quality when knocked together give a clear ringing sound. The ordinary red brick is generally more absorbent of moisture than the hard stock brick, and is commonly only used for ornamental purposes.

The relative conductivity for heat of brick as compared with other materials, is shewn in the following table, from Galton, which gives the units of heat transmitted per square foot per hour by

a plate 1 inch thick, the two surfaces differing in temperature 1° Fahr. :—

Stone—ordinary free stone	13·68
Glass	6·6
Brickwork	4·83
Plaster	3·86
Fir Planks	1·37
Brick Dust	1·33

It is evident that in this respect, brick walls compare very favourably with stone walls, and are much more economical of heat. Increased conductivity of a material may be counteracted by increased thickness.

Brick is very porous, as shewn by its power to absorb moisture. A good brick can suck up from 10 to 20 per cent. of its weight of water; while good granite only takes up ½ per cent., sandstone usually from 8 to 10 per cent., marble only a trace, and Portland limestone 13½ per cent.

Being porous, brick allows the passage of a considerable amount of air, unless its pores are occupied by moisture. The following table, from Galton, shews the number of cubic feet of air which every hour pass through a square yard of wall-surface of equal thicknesses, built of the following materials, there being a temperature of 72° Fahr. on one side the wall, and of 40° on the other :—

Wall built of	*brick*	7·9	*cubic feet.*
,,	*quarried limestone*	6·5	,,
,,	*sandstone*	4·7	,,
,,	*limestone*	10·1	,,
,,	*mud*	14·4	,,

Mortar should consist of clean sharp sand and slaked lime, usually in the proportion of three of the former to one of the latter. Grouting, or liquid mortar, is merely ordinary mortar to which a larger quantity of water has been added. It is used

for filling up the crevices between the brickwork about every fourth course.

The sand used in mortar should be free from small stones. It should not contain any earthy or clayey matters, as these greatly diminish the adhesive quality of the mortar, which depends on the union of the sand and lime. Hence, it is desirable to wash all the sand used in a building, in order to remove mud and clay. Many builders use an inferior mortar, in which other materials, such as "road scrapings," are substituted for sand. Such mortar is largely used by speculative builders of suburban houses. Another feature of their work is the placing of a thick layer of this inferior mortar between the bricks, instead of only sufficient to produce adhesion and equally distribute the pressure. This readily absorbs a driving rain, and after a frost crumbles away. If good mortar is used, it will throw off the rain, and last for an indefinite time.

The lime intended for mixing with sand, should be mixed immediately after slaking, and used without delay, before it absorbs carbonic acid from the atmosphere. Thus used, it increases in strength and solidity with time. It also furnishes a means of purifying the atmosphere of a house, until all the lime has combined with carbonic acid. Sand taken from the sea-shore is unfit for making mortar, as the salt contained in it is apt to deliquesce and weaken the mortar.

Common mortar crumbles away, if laid under water before it has had time to harden. Water cements, called also *Roman cements*, will harden under water. Baked clay and the common greenstone afford the basis of tolerable water cements, when mixed with lime, though they are less durable than ordinary mortar in the open air. The Romans employed a peculiar earth, obtained at the town of Puteoli, in making their water cements; this earth being of a clayey as well as siliceous character. It was extraordinarily hard and resistant to changes, and must by no means be confounded with the modern "Roman cement."

Stone varies very greatly in character, and in deciding which variety to use, great judgment is required to ensure that the one chosen shall be competent to resist the decomposing influences to which it will be subjected. It is uncommon for the whole thickness of the walls of a house to be built of stone; usually there is merely a facing of stone and a backing of brickwork. If good stone is not available, the less it is used the better. Most of the soft Bath stone, commonly seen about the windows of small suburban villas to give them an attractive appearance, crumbles away rapidly, and requires to be replaced by other stones long before the ground-lease is exhausted.

The stone chosen should be durable, and able to resist the action of the sulphuric, sulphurous, and carbonic acids absorbed from the atmosphere, and brought in contact with it by means of rain. The stone of which a considerable part of the Houses of Parliament consists is dolomite, a double carbonate of lime and magnesia. The acid fumes in the air produce on its surface soluble sulphate of magnesia (Epsom salts), which is washed away in successive layers.

It is very desirable also that, if the stone presents any stratification, it should be laid in the wall in the same position as that in which it was originally deposited in the quarry. Thus, any planes of stratification will be horizontal, and there will be no tendency to scale off by the action of frost and rain. Comparatively homogeneous stones, such as granite and millstone-grit, can be laid in any position. In testing the character of any stone, the least porous, densest, and most resisting to crushing, will as a rule be the most durable.

Stones are used in dwelling-houses for ornamental purposes, or for building the walls, roof, floor, steps, etc.

For ornamental purposes, granite, and the numerous stones classed under the broad name of marble, are employed. Enamelled slate is frequently used as a cheap imitation of black marble, for chimney-pieces and other purposes. The use of granite or marble is greatly limited by its expense.

The chief difficulty in the use of stone for the walls of houses, is that of keeping out the wet. To obviate this, stone-houses are often built of great thickness, and are thus kept cooler in summer and warmer in winter.

In and near large towns brick is chiefly used for walls of houses, and stone employed only for window-sills, columns, steps, etc. It is even more important in these cases to carefully select the stone, as the parts where it is placed are those most exposed to the weather. If a soft, friable freestone is used, after a sharp frost large scales are seen falling off in flakes, owing to the freezing and subsequent thawing of the moisture in the stone.

Portland stone is the best-wearing stone to be had in the neighbourhood of London. *Bath stone* is also considerably used, but as it varies greatly in quality, should be very carefully selected. For landing-steps and paving, *Yorkshire stone* is extensively used. Other varieties of stone are employed; and it may be stated generally, that most kinds of stone can only be economically used near the quarries from which they are derived.

Limestones were recommended by the Commissioners appointed to select the most suitable stone for the Houses of Parliament, in preference to sandstones, on account of their general uniformity of tint, comparatively homogeneous structure, and the ease with which they can be converted to building purposes. The result has not justified their use; but it appears that the actual limestone used was derived from a different stratum to that selected.

Stones do not withstand fire so well as bricks, which are already burnt. This was remarkably shewn in the great Chicago fire. Limestone is more fire-proof than sandstone.

Several kinds of *artificial stone* have been introduced. Their wearing qualities are as yet doubtful, and they are very costly.

In addition to the stones already named, there are slates and tile-stones, only used for roofing purposes.

The *Slate* used for roofs is an altered form of clay, possessing a

laminated structure. The ease with which it splits along the planes, renders it peculiarly suitable for this purpose. The Welsh slates are considered the best.

Tile Stones are thin bedded sandstones. They are heavier than ordinary slates, and have been largely superseded by them, though still used in some parts of the country, where they are cheaper than slate. Their weight is a great drawback to their use, but they preserve the interior of a house from excessive heat and cold much better than slate.

Flintwork is sometimes used in erecting smaller buildings. A large amount of mortar requires to be used; hence building with this material must be proceeded with slowly, in order to allow time for setting. Occasionally, buildings erected with walls of this description have completely failed, owing to a continuance of wet weather preventing the mortar setting. Houses built with flintwork should always contain one-fifth of their bulk of brick-work.

Concrete forms an almost essential part of the foundations of a house. The walls also may be built of it, and this plan has been largely adopted of late years. The concrete for this purpose should be formed of cement, as this hardens more rapidly than ordinary lime, and being harder when it is set, ensures a more secure building. If concrete walls are made of good materials, they often keep out the weather more effectually than brick walls of the same thickness. The concrete walls are built inside a plank or iron framework, the frame being fixed at higher levels after each portion is set.

Concrete, as its name indicates, is a mixture of different substances; a cement, and a substance to be cemented or aggregate. The aggregate most commonly used is gravel, from which the fine sand has been separated. This material, however, does not furnish nearly so good a hold for the cement, as stone, burnt ballast, broken pottery, coke, or slag. All these require crushing, and it is important that they should be in angular pieces. Either lime or cement is employed as a matrix. Lime answers for ordinary

purposes, but Portland cement should always be used when great strength is required. It appears that old cement, while taking longer to set, in the end sets harder than fresh cement.

The chief objections to concrete for house walls, are the difficulty and cost in making alterations, and the necessity for some ornamental finishing.

On the other hand, it presents some great advantages. Thus, it is porous, and yet it appears to resist saturation by water. Professor Pettenkofer found that bricks made with clay were completely soaked with water in from 9 to 12 hours, while under similar conditions it took 55 to 190 hours to saturate a slag brick (composed of concrete, in which the aggregate is the slag from iron furnaces). If these statements are confirmed, slag bricks and concrete materials generally will be invaluable for building purposes.

Concrete again (like fire-clay) is extremely resistant to heat, and is practically fire-proof. For hospitals and similar buildings it presents great advantages; for not only is the building washable in every part, so that water can be freely used; but if disinfection is necessary, it can be raised by artificial means to a sufficiently high temperature for this purpose, without in any way injuring its structure; and can thus be rendered habitable a few hours after a fever patient has left it.

Mr. Lascelles has devised a system of building houses in concrete, which obviates the necessity of using a single piece of timber. The walls consist of two layers of concrete, with an air-space between; the floors are formed of concrete slabs, which are waterproof, and do not allow the penetration of dust; while the roof is formed of Staffordshire tiles.

Half-timber Work consists of a combination of timber and brickwork. It is very picturesque, and specimens of it are still to be seen in many country towns. The introduction of timber into the walls greatly increases the danger from fire. When houses are built in contact, the timber framing of the two ought not to touch.

Terra-cotta has been quite extensively used of late years for building purposes. It is made from certain kinds of clay, mixed with glass, pottery, sand, or similar materials; then ground up, strained, and kneaded; and lastly thrown into moulds and baked in a kiln. The unequal shrinking of the clay is a great difficulty in its manufacture. It is susceptible of great varieties of ornamental treatment. Its durability when exposed to the influences of a town atmosphere has not yet been completely established.

Iron and **Wood** have occasionally been employed alone in building houses. The former, owing to its good conducting powers for heat, is cold in winter and hot in summer; while the latter becomes rotten from exposure to wet, and is also very combustible.

For roofs, slates or tiles are the materials most frequently employed; but occasionally lead, zinc, and even copper are used; thatch in country places, and tarred felt for temporary buildings.

Lead is the most suitable metallic covering for roofs, as it is durable and easily worked. It is, however, heavy, and demands considerable strength in the timbers by which it is supported. **Zinc** has been largely used of late. It is cheaper and lighter than lead, and its durability is said to be greatly increased by improved methods of manufacture. Both lead and zinc require very careful laying, and are chiefly appropriate for flat roofs. Copper nails should not be used to fix such roofs, on account of the destructive galvanic action set up by contact of two dissimilar metals in presence of the acids contained in the atmosphere.

Thatch makes a most comfortable roof, protecting the interior of the house from extremes of heat and cold. It is, however, very unsanitary. Being composed of vegetable matter, the alternate wet and warmth to which it is subjected, cause its decomposition. It is also very inflammable, and may easily be ignited by sparks from the chimney in dry weather. It forms a favourite home of insects, and is frequently fouled or otherwise injured by birds.

Various kinds of Plaster are applied to the interior of walls, for the sake of warmth, cleanliness, or appearance, lime or cement forming an important part of their constitution. The plastered surface is healthy, in proportion to its hardness and density, and capacity for taking polish. If the plaster is porous, it absorbs organic impurities from respiration and other sources, and finally becomes saturated with them. Where a room is white-washed at intervals, the wall can be cleansed from its impurities each time this is done; but where the plaster is covered with a paper, it is highly desirable that the plaster should be as hard and unabsorbent as possible, in order that all impurities may be removed by changing the paper.

In houses built by speculative builders, the plaster most commonly used consists of a mixture of lime with sifted vegetable mould, or even of worse materials. The result is a composition which, unless supported by the wall-papering, becomes rapidly damaged.

Ordinary plaster consists usually of three layers. The first is laid on with a mixture of about equal parts of lime and sand with long ox-hairs. The second coat consists of slaked lime, mixed to the consistency of cream, with a little hair added. The last or setting coat consists of a thin layer of lime and water, prepared in a somewhat different way to the previous coat, and called plasterers' putty. Some plaster of Paris (gypsum) may be added, to ensure rapid setting, but it should only be used in small quantities.

Keene's cement, Martin's cement, and Parian cement are all mixtures of calcined gypsum and other substances; Keene's cement being the hardest, and capable of receiving a high polish. Parian cement is said not to produce such sharp angles or mouldings as the other two.

Selenitic cement contains a small proportion of plaster of Paris ground along with lime. Lime may also be selenised by the addition of any other sulphate, or of sulphuric acid. The presence

of the sulphate causes the cement to set much more quickly, and enables it to be used with a larger proportion of sand than ordinary lime.

CHAPTER XXIX.

CONSTRUCTION OF THE HOUSE.

The Primary Requisites of a House.—The Foundation.—Concrete Bed and Dry Area.—Damp-proof Course.—Causes of Damp Walls.—Internal Wall Surface.—Paints.—Wall-papers.—Arsenic in Papers and Paints.—Floors.—Wood Floors.—Carpets.—The Roof.

In preparing to build a house, or in entering into a house already built, it is important that the following requisites should each receive careful attention:—

1. The site of the house should be healthy, and its relation to surrounding objects in accordance with the laws of health. These points will be considered in the next chapters.
2. The house should be warm in winter, and cool in summer.
3. It should be always dry.
4. There should be an abundant and uninterrupted supply of air.
5. The water supply should be abundant, conveniently arranged, and pure.
6. The excreta and waste-water should be immediately removed from the house and its annexa.

The three last requisites have already received consideration. Of those still to be considered, **dryness** is the most important. A damp house is certain to be an unhealthy one. Rheumatic and other affections are set up, the real cause of which in the walls and floors, is commonly unsuspected. Damp in the walls has another disadvantage. If the pores of the bricks are occupied by water, air cannot pass through, and thus the ventilation and purification of the house are greatly impeded. Damp may arise either from the ground on which a house stands, or from the rain beating

against the walls. Unless special means are taken to prevent it, moisture rises through brick after brick, just as it would rise through a series of lumps of sugar resting on one another, and in contact below with a little water. In both cases, capillary attraction causes the moisture to spread in all directions.

It will be convenient to consider in order the foundation, floors, walls, and ceilings of rooms, discussing the various points bearing on health.

The **Foundation** requires to be solid and substantial, otherwise sinking occurs, with cracking of the walls, resulting in an unsafe condition, and an exposure to rain and wind.

In making the foundation for a house, the ground should be excavated, so as to secure a solid bed of earth or rock not liable to be affected by the weather. A continuous bed of the best concrete should then be laid, extending on every side at least 6 inches beyond the frontage of the wall; and it should never be less than 18 inches thick (Gordon Smith), though commonly it is not made thicker than 6 inches. The concrete serves two purposes: it, to a large extent, cuts off the entrance of the ground-air through the basement floor into the house; and prevents the entrance of damp into the house from the basement or along the walls. It does not however completely ensure these objects; and it is essential, therefore, that the floor should have an air space under it to secure free ventilation. Asphalte is more impervious than concrete, and is sometimes substituted for it in making foundations.

The cutting off of the ground-air from the house is extremely important. The concrete foundation helps this to a certain extent, and while the concrete is recent, its lime serves to neutralise the carbonic acid of the ground-air. It may be done much more effectually by building the basement on open arches, as is commonly done in France.

Free circulation of external air should be allowed around the basement of a house. For this purpose a *dry area* should always be provided, that is, a closed chamber lined with stone or cement,

below the ground level of the house, and surrounding its four walls. This allows air to enter, and prevents contact of the soil with the walls of the house.

The Walls of a house require to be as carefully constructed as the foundation. The portion of the wall below the level of the ground should be constructed of damp-proof materials as well as surrounded by the dry area already named. The "*damp-proof course*" should be carried through the whole thickness of the walls, slightly above the highest point at which the ground is touched. It may be formed by (1) sheet lead, which possesses the disadvantage of being costly; (2) two layers of ordinary roofing slate, in cement; (3) a layer of good asphalte, about $\frac{3}{4}$-inch thick; (4) perforated glazed stoneware slabs; or (5) two or three courses of hard blue Staffordshire bricks, laid without mortar. The use of asphalte is an excellent plan, and is now commonly adopted in good buildings.

The damp-proof course protects the walls from damp proceeding from the soil around or beneath the house.

It is necessary also that the walls above the level of the ground should, as far as possible, be kept free from damp. *Damp walls*, not due to ascent of moisture, *may be caused by*—

(1) Rain falling on window-sills which do not project beyond the walls, and consequently do not throw the water clear of them. This is remedied by constructing the window-sills so as to project beyond the walls.

(2) Rain falling on cornices and other projecting portions of the wall itself. The evil from this source may be diminished by sloping the top of the projection, downwards from the face of the wall. The mortar joints in such projections always tend to become loosened, and the evil is commonly aggravated by using a softer sort of brick at these points.

(3) Parapet walls, gables, etc., not being properly covered with coping. All such walls should be topped with a projecting slab of stone.

(4) Overflow from defective roof-gutters or rain-water pipes. In this case, either clearing out, repairing, or renewing is required.

(5) Rain beating against the walls. This as a rule produces no great harm, if the walls are well constructed. Most of the water runs off as it falls on the surface. It is advisable however to protect a much exposed wall by a coating of Portland cement, or in extreme cases with slate. Various impervious paints have also been employed.

If it is not proposed to coat exposed surfaces of brickwork, the wall may be formed of two parallel walls, two or three inches apart, and tied together by a sufficient number of bonding-ties of iron or glazed stoneware, or some other non-absorbent material.

In a few instances, the narrow space between two such walls has been filled in, as the work proceeded, with asphalte or slab slate, thus forming a *vertical damp course.*

The evils arising from damp can be avoided in every new house by proper methods of construction. In an old house, however they are much more difficult to remove. The dampness is indicated on entering, by a peculiar mouldy smell, and by the discolouration and destruction of wall-papers, and dry rotting of floor timbers. In such a case, a damp course may, with care and patience, be inserted in the wall, and the soil under the basement may be laid with concrete, and a dry-area excavated around the basement.

Damp walls, besides being unhealthy, are decidedly uneconomical, as they absorb a large amount of heat in the process of evaporation of the moisture. New walls always contain a large amount of moisture. A common brick will absorb and contain within itself a pint of water; granite about one-tenth of this amount. Thus an eleven-roomed house containing from 120,000 to 150,000 bricks is capable of absorbing 17,000 gallons of water. This amount of water has to be evaporated before the house is fit for habitation. The larger the volume of air and the higher its temperature, the quicker this will occur.

The *thickness* of the walls of a house requires to be sufficient to ensure stability, to keep out the damp, and to prevent a too rapid loss of heat from the walls. The relative merits of the different materials employed for these purposes have been already considered. A thin-walled house is hot in summer, and cold in winter. The upper stories of houses are often built with too thin walls, the result being chilly bedrooms. A single-brick wall (9 inches thick) will rarely keep out the weather effectually, and frequently a brick-and-a-half wall (14 inches thick) is insufficient for this purpose. The bricks should be so interlaced as to "bond" or tie the wall together in all directions. The strength of walls may be increased by the introduction of timber or hoop-iron between the inner and outer layers; the latter is preferable, as timber tends to rot, and is dangerous in case of fire.

In the construction of fire-places and chimneys, it is important to avoid the proximity of timber and wood-work to the inside of flues, as this is a common cause of fires.

The **internal wall-surface** for a dwelling should be, as far as possible, impervious to moisture, in order that respiratory and other impurities may not soak into it, and that it may be washed with soap and water at frequent intervals. Polished Parian cement is practically impervious, but is costly. Glazed bricks or tiles are also impervious, but the cement of the joints is porous, and harbours impurities.

The next most impervious treatment for a wall is painting, and after this distempering; paper being the most absorbent coating.

The plaster of a room, if left unprotected, absorbs a large amount of organic impurities. In an analysis of the plaster of a hospital wall, 46 per cent. of organic matter was found.

Whitewash is a mixture of ordinary lime and water. *Colour-wash* is the same, with the addition of some cheap colour. *Distempering* is done with whiting and size, colour being added.

By painting and varnishing the walls of a room repeatedly, they

may be made impervious for a time; though they are liable to be damaged, and then absorb organic impurities more easily.

Paints, whether used for wood-work or walls, most commonly contain white lead (carbonate of lead) as their base. This presents two great disadvantages. When exposed to the fumes of sulphur compounds, in sewer emanations, or the air of large towns, or evolved from decaying vegetable matter, it is apt to become black in spots, owing to the formation of black sulphide of lead. If iron is painted with lead paint, an injurious galvanic action is set up between them. The chief objection to lead paint, however, is its poisonous character. Colic, and other complaints due to lead, have been produced by sleeping in a newly-painted room, apparently from a certain amount of lead getting into the atmosphere along with turpentine.

Various *substitutes* have been proposed *for lead paints*. Mr. Wilkins used kaolin (the china clay of Cornwall, a decomposed granite), mixed with a little zinc white, as the base. The oxy-sulphide of zinc ("Charlton white") is also employed, and seems to possess great advantages.

Coloured paints are produced from white paint by the addition of various pigments. Green paints should be carefully investigated as to the presence of arsenic, which will produce arsenical poisoning. Vienna green, Scheele's green, and emerald green (arsenites of copper) are all poisonous; while Brunswick green, mineral green, and chrome green are non-poisonous. Salts of lead, arsenic, copper, and antimony are used in different ways, to give brilliancy to many colours.

The *Silicate Paint* Company manufacture paints into which none of these poisons enter, and it is also claimed for them that they withstand 200° of heat without blistering, and have no chemical action on metals. The silicate enamel is a substitute for the more expensive ordinary enamelling. It produces an impervious washable surface, and can also be used externally for damp walls.

The *Torbay oxide paint* is used for preserving iron. It is a natural combination of oxide of iron with silica, alumina, and a trace of magnesia. The use of *luminous paint* (a preparation of sulphur and lime) for bedrooms, water-closets, the names of streets, etc., is likely to prove very useful.

Asbestos fire-proof paint renders wood-work practically uninflammable. All the wooden buildings of the Fisheries' Exhibition were covered with this material, thus securing a material reduction in the amount of insurance premium required.

Varnish is a preparation of rosin dissolved in oil, turpentine, or alcohol. In order to render the surface non-porous, one or two coats of size should be applied before the varnish.

Painting wood or iron-work is valuable, not only as a preservative from the effects of the weather and the oxidising action of the air, but also because it tends, to a large extent, to prevent the absorption of organic matters; and its surface can be frequently cleansed.

Paper is the material most commonly employed for covering walls. It is, unfortunately, much more absorbent and retentive of moisture than paint or distemper; but, on the other hand, it is much more cheerful and warm in general appearance, and more suitable than paint for walls in which the plaster-work is not perfectly smooth. It is also less expensive.

Light-coloured papers should be chosen, as they are more cheerful, and are not so likely to harbour dust. Glaring patterns are objectionable, as they tire the eyes. The paper should not present any surface-projection for the lodgment of dust. Flock-papers are especially objectionable in this respect. Stamped papers and imitation leather papers, although presenting inequalities of surface, can be readily cleansed. Some papers are particularly prone to absorb moisture, and should, therefore, be avoided. Among these are the so-called satin-papers, or those which have a polished surface like the French imitation satin.

In bath-rooms and water-closets, the wall-surface should be as non-absorbent as possible. Paper, unless varnished, should be

therefore avoided as far as possible. The best covering for these places is glazed tiling.

Much illness may result from the use of putrid size and paste in hanging wall-papers. Several cases of illness have been traced to the putrefactive odours arising from such sources.

Not uncommonly, a new paper is pasted over an old one; and this may be repeated several times. Remembering that the paper itself is almost entirely composed of vegetable substances, and that the paste also is vegetable, it is not strange that intolerable stenches have been produced by the decomposition of some half-dozen layers of paper. Before new papering is put on, the walls should be cleared of all vestiges of the old, thoroughly washed down, and subsequently coated with size (that is, "clear coloured"). The sizing diminishes the absorptive power of the wall, and gives a good surface for applying the paper.

Bed-room papers require to be more frequently changed than those of other rooms. Bed-rooms in regular use should be re-papered at least every two years. It is still better to use distemper for such rooms, as this can be washed off in a few hours with comparatively little expense, and can be made of any tint desired.

Rooms in the basement should not be papered, as the walls require frequent washing down and cleaning. Here also distemper colour can be used.

Various kinds of paper are now sold which are washable, and are said to be non-absorbent. Some of them require varnishing; others do not. Such papers are certainly cleaner than ordinary paper; but it would not be safe to trust to their non-absorptive character. "Lincrusta Walton" is probably non-absorbent, and can be scrubbed with soap and water; but it is expensive. If a case of infectious fever occur in a room, the papering should in every instance be removed.

Arsenic in Wall-Papers and Paints has been a not uncommon source of prolonged ill-health—the cause of which has possibly not been detected until the illness disappears, when the offending room

is vacated for a period. The symptoms produced vary greatly, and may closely simulate those of different diseases. In some cases repeated attacks of diarrhœa and abdominal pain occur. Or there may be nausea, headache, frequent griping pains, and loss of appetite. In other cases restlessness, loss of sleep, and general malaise are the chief symptoms, with the occasional addition of conjunctivitis (superficial inflammation of the eye). Out of 100 cases collected and reported on by a Committee of the Medical Society of London, diarrhœa, nausea, and intestinal mischief occurred in 85; severe depression in 16; conjunctivitis in 19; and cough, asthma, etc., in 9.

The severity of the symptoms produced will vary with the amount of arsenic contained in the paper, and the length of time daily that the patient is exposed to the fumes.

Some persons again are much less susceptible to the influence of arsenic than others. This will explain why some escape while occupying the same room in which others suffer severely. More commonly, however, the exemption is due to shorter exposure.

The most dangerous and most commonly used preparation in wall-paper printing is Scheele's green (arsenite of copper). Besides this, there is emerald-green—an aceto-arsenite of copper—for producing more delicate tints. Aniline dyes, especially the red, often contain much arsenious acid (white arsenic). The arsenic compound is made to adhere to the paper by size or some other material. When dry, it cracks and peels off, and minute particles get into the air as dust. In addition, arsenic compounds easily volatilise, and become diffused in a gaseous condition throughout the atmosphere of a room, even when its temperature is not greatly raised. The virulence of the arsenical colouring is in proportion to its volatility. Arsenic seems to be much more dangerous when associated with size. It has been shewn that a mixture of white arsenic and starch paste, or other organic substance, leads to the formation of gaseous arseniuretted hydrogen, while this does not occur when no organic matter is present (Dr. Fleck). Distemper frequently contains

arsenic, and as it also contains size, arseniurretted hydrogen is liable to be given off at any time. Size is largely used for fixing colours; thus, the proper conditions for the development of arseniuretted hydrogen—the most dangerous compound of arsenic—are present. As much as 17 grains of arsenic have been discovered in each square foot of a wall-paper. Now, arsenic is sometimes given internally for certain skin and other diseases, but the dose is only from $\frac{1}{60}$ to $\frac{1}{12}$ grain; the capacity for poisoning of such a paper as the above will therefore be evident.

Papers of other colours than green have been found to contain dangerous quantities of arsenic; thus blue, mauve, red, and brown, may contain large quantities; the delicate greys often yield a considerable amount, and some white papers are heavily loaded with it. We may mention, in passing, that arsenic is occasionally present in stockings and other wearing apparel, artificial flowers, toys, etc. In these cases, it may produce irritation of the skin, and even eczema (an inflammation of the skin).

Considering the severe illness that may be produced by the arsenic derived from wall-papers and paints, and that such illness has in some cases proved fatal, it is surely time that the Legislature should interfere, and entirely interdict the use of arsenical pigments. In other countries, this has already been effected; in Bavaria, as long ago as 1845; while in France, Prussia, and Sweden, stringent laws forbidding the sale of arsenical papers are in force.

It is always wise in buying a paper to obtain a voucher that there is no arsenic in it; though this ought to be confirmed by an analysis, as in many cases where the voucher has been readily given, an abundance of arsenic has been discovered. Green and all other colours can easily be produced without the help of arsenic, and are so by the more respectable firms.

The presence of **arsenic may be detected** by the test commonly known as Reinsch's. A portion of the suspected paper (two or three inches square) is cut into small pieces, and placed in a good-sized test tube; water is added until the tube is about a third full

and then one or two teaspoonfuls of pure hydrochloric acid, and a small piece of pure copper foil. If the test tube is now heated for a few minutes by a spirit lamp, arsenic, if present, will be deposited as a black or dark steel-coloured coating on the copper. A mere tarnish of the copper must not be accepted as evidence of the presence of arsenic, but an almost complete obliteration of the colour of the copper.

This test may be confirmed by taking the copper covered with arsenic, drying it, and then heating in a perfectly dry test tube. Crystals of white arsenic, which may be identified under the microscope, will be deposited higher up in the tube.

Marsh's test may also be employed, if further confirmation is required. In this, the ordinary apparatus for developing hydrogen by the action of diluted sulphuric acid on zinc is employed, the suspected paper being inserted in the bottle. The hydrogen coming off is burnt, and a clean porcelain surface is applied to the flame. If there is arsenic in it, it is deposited on the porcelain.

Floors are generally made of wood, stone, or tile. Wood is certainly the best for comfort, the others being cold to the feet. A tiled floor may be warmed according to the old Roman plan; a hollow space, or flues, being carried under the floor, and warmed by heated gases from a furnace.

For *basement floors* wood is not to be recommended, as it tends to rot from the damp, and very easily admits the ground-air into the house, especially in the too numerous cases where no concrete or asphalte foundation has been laid. Stone or glazed tile is preferable, but should be covered with some warmer material.

The use of *concrete* for basement and other floors is becoming common. It is porous, and yet resists saturation with water, while it is one of the best protections against the extension of a fire from floor to floor.

Other materials have repeatedly failed in cases of severe fire. Cast-iron is commonly employed to strengthen walls and floors; but at 212° Fahr. it loses about 15 per cent. of its strength, and at

the temperature of the centre of a large fire is in a molten condition. When imbedded in concrete or fire-clay, however, iron girdles effectually resist a tremendous heat. Stone and brick do not offer any effectual resistance to the spread of a fire, and timber joists carry it from room to room with great rapidity. For all these reasons, it is probable that in future, floors will more frequently be made of concrete.

Wood Floors.—The timber employed should be close and straight in grain, having a glossy surface, and uniform colour. There are two chief groups of timbers. (1) Coniferous timbers—pine, fir, cedar, larch, etc. (2) Hard or non-coniferous timbers—oak, ash, beech, mahogany, walnut, elm, etc.

Even the best timbers are liable to rot and decay, unless precautions are adopted. The chief causes which tend to induce rotting, are damp walls, lack of ventilation, contact with mortar, damp earth, or vegetable mould, and worst of all, alternations of damp and dryness, or wet along with heat.

In order to avoid these dangers, the ends of all timbers resting on walls should have a clear air-space around them, and communicate with the external air by means of perforated bricks. The larger timbers, girders, etc., should rest on stone templates, and the smaller joists on hoop-iron bonds. The ends of oak posts, which are to be driven into the ground, should be charred, if the timber is old, or steeped in a solution of chloride of zinc. In all cases, the timber used should be well seasoned, and properly ventilated.

The floor should consist of a double row of beams, or "joists," to the upper surface of which boarding is fixed. Where fire-places and flues occur in the wall to which the joists are fixed, it is important that the ends of the joists should be kept at a sufficient distance.

In all cases the boards of the floor should be so closely in contact, that dust or particles of any kind cannot fall between. Such matters are liable to decompose and vitiate the atmosphere, as well as injuring the ceiling beneath. Various methods for

ensuring the exact juxtaposition of the boards are employed in the best houses, but need not be described.

The frequent washing of a wooden floor, to keep it clean, is unadvisable, as the wood absorbs the moisture and diffuses damp throughout the room. For hospitals this is especially important; it is much better to have the floors polished, in order that they may be dry cleaned. Oak, or some other hard wood, made with close joints, and then oiled and beeswaxed and rubbed to a polish, makes a good and almost non-absorptive floor. (Galton). One of the best floors is made of concrete, with iron joists, and oak boards laid above this.

A bad floor may be economically made non-absorptive by covering the rough deal boards with thin, closely-adapted oak boards, oiled and beeswaxed.

Carpets are commonly made to cover the entire floor of rooms. This cannot be too much deprecated. Carpets, like curtains, are mere dirt-traps, which become loaded with filth of every description. This is abundantly proved when a carpet is swept, and the dust allowed to settle on all the articles in the room. Such dust, if examined, will be found to consist of dried mud, chiefly granite or wood, but also containing every description of vegetable and animal impurities. When raised by walking about a room, it is a common cause of "colds" and bronchitis. In addition, as it consists largely of organic matter, it produces a close smell and devitalises the entering air.

The substitution of a central carpet, for one covering the entire floor, is a great improvement, the floor around the carpet being covered with parquet veneering; or if the expense of this be too great, the whole floor may be painted with four good coats of dark oil paint, and varnished, the joints of the boards having first been made secure.

The carpet should be easily removable, in order that it and the floor may be thoroughly cleaned at intervals.

In bedrooms, the less carpet the better. Good Chinese or Indian

matting is strongly recommended instead, as it does not retain the dust and other impurities which become fixed in the woolly texture of a carpet. (Edis).

Oil-cloth, linoleum, and similar materials are in common use for covering halls, passages, etc. When laid over the whole surface of wooden floors and glued down, they tend to promote dry rot in the floors, by keeping in the moisture and not allowing the access of air. Occasionally, linoleum is laid with cement, so as to fix it evenly to the floor-surface. This is ruinous to a wood floor. Linoleum may be safely used, if it is only laid over the central parts of a floor, and simply fastened down with pins.

The **Roof** of a house should be quite impervious to rain. It is usually constructed of tiles or slates; lead or zinc being employed for flat roofs.

The down spouts, for carrying off rain-water from the roofs, should be fixed two or three inches away from the wall, in order that in case of overflow, the water may not soak into the wall.

In order to diminish the loss of heat through the roof, which may be considerable, if the upper rooms are without special protection, the roof should be built with close boards covered with felt, under the slates or tiles. Such a method of construction also prevents excessive penetration of summer heat.

The ordinary lath and plaster *ceiling* serves to deaden the sounds in rooms overhead, and is a good non-conductor of heat. It allows, however, considerable passage of air and moisture. When the external temperature was 72° and the internal 40° Fahr., $1\frac{1}{2}$ cubic feet of air per square foot of plaster were found to pass through every hour.

CHAPTER XXX.

THE SOIL AND ITS DRAINAGE.

The Varieties of Soil.—Their Suitability for a Site.—Ground Air.—Water in the Soil.—Moisture and Ground Water.—The Level of Ground Water.—Temperature of the Soil.—Connection of Ague, Typhoid, Cholera, Consumption, etc., with Conditions of the Soil.—Sub-Soil Drainage.

It will be convenient to consider in turn the geological varieties of soil; the air contained in soil; the water contained in soil; and the temperature of various soils.

THE VARIETIES OF SOIL.—1. **Granitic, Metamorphic,** and **Trap Rocks** usually form healthy sites for houses. The slope is generally great, and the ground air consequently dry.

2. **Clay Slate** resembles the last in its effects on health. Water is, however, often scarce, owing to the impermeability of the rocks, and for the same reason occasional floods occur.

3. **Limestone** and **Magnesian Limestone Rocks** resemble the last in possessing considerable slope, so that the water passes away quickly. The hard oolite is the best formation under this head, and magnesian limestone the worst. The absence of marsh from these formations should be carefully ascertained.

4. **Chalk Soil** is healthy when unmixed with clay, and permeable. Goitre is not so common as in limestone districts. If the chalk be mixed with clay, it is often damp and cold.

5. **The Sandstones,** if permeable are healthy, soil and air being dry. If mixed with clay, or if clay lie under a shallow layer of sand-rock, the site may be damp. The hard millstone grit is a healthy formation.

6. **Gravels** of any depth are healthy, unless they lie below the surrounding surface, and water rises in them.

7. **Sands** may either be healthy or unhealthy. They are healthy when of considerable depth, and unmixed with organic matter; unhealthy when, as in the French Landes, they contain a large

amount of vegetable sediment. They may also be unhealthy from being shallow, and lying on a clay basis; or from the ground water rising through them from ground at a higher level; or from the sand containing considerable soluble mineral matter.

8. **Clay, Dense Marls, and Alluvial Soils generally**, are always suspicious. Water is retained in them, and is often very impure. Only very thorough drainage can make them healthy.

9. **Cultivated Soils** are not necessarily unhealthy; but

10. **Made Soils** are always to be carefully avoided, as sites for houses. The materials with which inequalities have been filled up are commonly the contents of dust-bins, or some other refuse. The gradual putrefaction of organic matters renders the air about the houses impure. Such soils require free sub-soil drainage, in order to keep them dry. It appears that the organic matters in soil are gradually removed by oxidation and other processes. At least three years should be allowed before any such site is built on.

The following table, prepared by Dr. Parkes, places different geological formations in their order of healthiness for the purposes of a site:—

	Permeability of Water.	Emanations into Air.
1. *Primitive rocks, clay slate, millstone grit*	Slight.	None.
2. *Gravel and loose sands, with permeable subsoils*	Great.	Slight.
3. *Sandstones*	Variable.	Slight.
4. *Limestones*	Moderate.	—
5. *Sands with impermeable subsoils*	Arrested by subsoils.	Considerable.
6. *Clays, marls, alluvial soils*	Slight.	Considerable.
7. *Marshes, when not peaty*	Slight.	Considerable.

The general geological conditions have an important bearing on the choice of a site for a house. The immediate local conditions

have, however, a still greater influence on its sanitary condition. These will be discussed in the next chapter.

The soil consists mainly of mineral matter. It also contains a certain proportion of animal and vegetable matters, and it is on the amount and character of these (along with the condition of moisture and aeration), that the healthiness of a given soil depends. The presence of vegetable matter, subject to alternate wettings and dryings, and to heat, seems to be the condition on which malaria depends. The presence of animal matters leads to the evolution of poisonous effluvia, and the tainting of drinking water. The two chief agencies at work to rid the soil of organic impurities, are oxidation and the influence of growing plants. The organic matters become oxidised into ammonia, nitrites, and nitrates, and these are eagerly assimilated by vegetation.

The Air contained in the Soil varies greatly in amount with the character of the soil, and with the level of the ground-water. As the ground-water rises the ground-air is driven out. Thus, after a heavy rainfall a large portion of this air will be displaced. Variations in barometric pressure, and a rise or fall of temperature, cause movements in ground-air. A house artificially warmed is continuously fed from the ground-air, unless means are adopted to make the floors impervious. The warmth of the house acts as an air-pump, aspirating the colder air into its interior. The air from cesspools or defective drains may be similarly aspirated into the house; and the same condition explains the unhealthiness of houses built on "made soils." For these reasons the occupation of cellars as lodging-houses has been prohibited by law. Coal gas has occasionally made its way into houses when not laid on to them, by percolation from leaky pipes in the street to the foundations. This has resulted in one instance in an explosion, and in others in poisoning by the gas.

The *amount* of ground-air varies greatly. Loose sands often contain 40 to 50 per cent., soft sandstone 20 to 40 per cent., and loose surface-soil many times its own volume.

The *nature* of the air is not accurately known. It is, however, extremely rich in carbonic acid, of which it contains 4, or even

6 to 8, per cent. The more porous the soil, the quicker the oxidation of organic matters, and consequent purification of the soil.

The Water contained in the Soil is divided into moisture and ground or subsoil-water. When air is present in the soil as well as water, the soil is merely moist. Pettenkofer defines the ground-water as that condition in which all the interstices are filled with water, so that, except in so far as its particles are separated by solid portions of soil, there is a continuous sheet of water.

The **Moisture** in the soil varies in amount. Open gravel will absorb from 9 to 13 per cent. by weight of water; gravelly surface soil 48 per cent.; light sandy soils from 23 to 36 per cent.; loamy soil 43 per cent.; stiff land and clay soils from 43·3 to 57·6 per cent.; sandy and peaty soils from 61·5 to 80 per cent.; peat 103 per cent. (B. Latham). The moisture being derived from the rainfall on one side, and the ground-water on the other, will vary with the amount of these. Some soils are practically *impermeable* to water, such as trap or metamorphic rocks, unweathered granite, hard limestone, and dense clay; while others, such as chalk, sand, sandstone, vegetable soils are *permeable.* Commonly the metamorphic rocks and hard limestones present fissures, which render them pervious. The rainfall which does not penetrate the soil flows into the streams and rivers at once, or is re-evaporated. On an average, it appears that in this country about two-thirds of the mean annual rainfall is at once evaporated. A smaller evaporation and a greater percolation take place in well-drained soils.

The **Ground-water** forms a subterranean sheet of water, which is in constant motion. There is first, of all, an irregular rise and fall of the water, according as it receives new additions from the rainfall, or loses a certain amount of its substance by percolation and evaporation; and there is, secondly, a constant movement toward the nearest water-course or the sea. In Munich, Pettenkofer reckoned the rate of this movement as 15 feet daily. It is impeded

by impermeability, or a deficient slope of the soil. The roots of trees also greatly impede its flow.

The level of the ground-water is constantly changing. The alteration in level may be only a few inches either way, while in some parts of India it is as much as 16 feet.

A *fall* in the level of the ground-water may be due to a dry season, or to improved subsoil drainage. A *rise* in its level is due to an increase in the rainfall, or some obstruction in the outflow, as from a swollen river. The tide may influence the level of the ground-water at a great distance. A sudden alteration in the level of the ground-water is a common cause of floods in mines.

The distance of the subsoil-water from the surface may be only two or three feet, or several hundred feet, the difference being due to the varying level of the nearest impervious stratum of soil. Its distance below the surface of the soil can easily be measured in any given case, by ascertaining that of the water of a shallow well in the neighbourhood. It should if possible never be nearer the surface than five or six feet. Sudden changes in the level of the ground-water from inundations render any soil unhealthy, and are even more objectionable than a persistently high level. This is especially true in the case of permeable soils. A sudden rising of ground-water expels the air in the soil, together with the associated effluvia; it also washes organic impurities out of the subsoil, and carries them into neighbouring wells. Several epidemics have been traced to this source.

The Temperature of the Soil varies greatly with its geological character, as well as with the temperature of the atmosphere. The daily changes in the temperature of the atmosphere do not affect the soil beyond a depth of about three feet. The annual changes in the atmosphere will affect the soil in a varying degree, the amount being dependent on the character of the soil as regards conductivity and retentiveness for heat. Such annual variations do not penetrate below forty feet, and are very small below twenty-four feet. The temperature of the earth increases with its depth,

the rate of increase in England being stated to be about 1° Fahr. for every 54½ feet.

In climates where, as in the British Isles, the rainfall does not vary very widely throughout the year, the average annual temperature of the soil will be identical with that of the atmosphere. In countries where snow lies for some time on the ground, the average temperature of the soil may exceed that of the air, snow being a bad conductor of heat.

In England the water of permanent springs has a temperature of 49° to 51° Fahr., and their water being derived from the deep part of the subsoil, its temperature may be assumed to represent accurately the mean temperature of the district.

Although the average temperature of any soil depends on the climate, soils conduct heat in a very varying degree, and therefore absorb unequal quantities. This has an important bearing on the comfort of those living on a particular soil. Schübler's experiments give the absorbing power of the chief kinds of soil, 100 being taken as the standard.

Sand, with some Lime	100	*Clayey Earth*	68·4
Pure Sand	95·6	*Pure Clay*	66·7
Light Clay	76·9	*Fine Chalk*	61·8
Gypsum	73·2	*Humus*	49·0
Heavy Clay	71·11		

It is evident from this table that sand is very retentive of heat, while clays and humus are very cold. Green vegetation lessens the absorbing power of the soil, and radiation of heat is more rapid, evaporation occurring constantly from the herbage. The influence of trees on the temperature of the soil will be considered later.

Damp soils are colder than dry soils. Buchan finds as the result of drainage of the soil, that (1) the mean temperature of arable land is raised 0·8° Fahr.; (2) cold is propagated more quickly through undrained land; (3) drained land loses less heat by evaporation; (4) the temperature of drained land is more equable, and

(5) in summer is often 1·5° to 3° above that of undrained land These facts throw considerable light on what will subsequently be said respecting consumption, rheumatism, etc.

Diseases Arising from the Soil.—The soil may be a cause of disease in two ways; either by means of the air, or the water it contains. Diseases due to contaminated drinking-water, have already been sufficiently considered. We shall therefore deal here exclusively with those attributed to **dampness** and **emanations** from the soil. The most important of these are malarious disease, typhoid fever, yellow fever, cholera, and dysentery, phthisis, and rheumatism. All of these are usually associated with the presence of organic matter in a state of decomposition, and in several of them (typhoid, yellow fever, cholera, and dysentery), contamination of the soil by the excreta of a patient suffering from the same disease, usually occurs.

(1) For the production of **malarious diseases** no such antecedent case is necessary. The soil must contain a certain proportion of dead organic matter; it must be exposed to alternations of heat and moisture, with a limited access of air, and a temperature of at least 65° F. Though most common in marshy districts, and in recent alluvial soils, malaria may develop in connection with any geological formation. That it may be removed by drainage of the subsoil, is well known. On the other hand, it has been traced in several instances to the construction of mill dams, etc., impeding the outflow of subsoil water; while it is common in the tropics, in the hot weather following the heavy rains.

(2) According to observations made by Pettenkofer in Munich, attacks of **typhoid fever** are connected with fluctuations of the subsoil-water, occurring when this is lowest. His observations have not been confirmed in this country; and there can be no doubt that the most common origin of this disease is from direct infection of water or milk by the specific contagion.

(3) In regard to **cholera**, Pettenkofer holds similar views. He advances many striking arguments to prove that, while cholera is

due to fermentation of cholera-stools, as agreed on all sides, the contagion can only be developed when there is a damp porous subsoil to receive the stools. There can be no doubt that under such conditions, the atmosphere would become impregnated with the cholera poison; but the water of the district would be still more likely to become tainted, and would form a ready means of communicating the disease. Pettenkofer however considers that the damp porous subsoil forms a second host in which the poison of cholera must pass through one stage of its existence, before it is again capable of producing the disease. Such an essential relationship of the soil is not borne out by observations in India.

(4) The close connection of **consumption** (phthisis) with a damp soil has been proved by Dr. Buchanan. After careful investigation he found that in the districts where improved sanitary arrangements had led to a drying of the soil, the death-rate from phthisis diminished; but where with sanitary improvements, the soil was not dried, the death-rate from phthisis remained stationary. In Salisbury, Ely, Rugby, and Banbury, the death-rate from phthisis decreased nearly 50 per cent. In other towns (such as Stafford, Morpeth), in which the same improvements had been made, with the single exception of not drying the soil, the death-rate remained the same. A subsequent investigation confirmed all these results, and shewed in detail the geological conditions which co-existed with a high phthisis death-rate. Dr. Bowditch, of Boston, U.S.A., independently arrived at similar conclusions, with regard to Massachusetts.

(5) Other diseases, such as **rheumatism**, **catarrh**, and **neuralgia**, are favoured if not produced by a damp soil. Since acute rheumatism is a frequent cause of heart disease, the latter may also be ascribed indirectly to a damp soil. How far these are due to chilling of the skin, and how far to other causes, is yet uncertain.

Drainage of the Soil.—There are two chief plans for rendering the soil drier—deep drainage and opening the outflow.

Sub-soil Drainage is of great importance in relation to health. There are two plans for doing this: either the sewers may be employed for this purpose, or a separate system of pervious drains may be laid. In order that sewers may be utilised for draining the soil, they must be penetrable to moisture. They are generally made so at their upper part, and water-tight below. This is, however, not a good plan. If the sewer is full, its contents soak into the surrounding soil, and contaminate it. In all new plans for drainage, there should be separate sub-soil drains. These should be constructed of brick or perforated earthenware; they should preferably be carried into the nearest water-course. If it is necessary to join them with a sewer, they should not pass directly into it, but into a disconnecting man-hole.

The importance of separate sub-soil drainage is shewn by the observation of Dr. Buchanan, that the death-rate from phthisis diminished more in the early years after the establishment of sewers than in later years; the difference being due to the tendency of the sewer-trunks to become consolidated and impervious to moisture (Baldwin Latham.)

Opening the Outflow, in order that water may not remain stagnant in the soil, is occasionally required. This may be done by clearing water-courses, removing obstructions, and forming fresh channels.

The provision of sufficient **surface-drains** to carry off ordinary water and storm-water, in order that percolation into the ground may be diminished, is also important.

Vegetation tends to diminish dampness of soil by causing rapid evaporation, and at the same time uses up the organic matter in the soil. Certain plants are more active in producing these effects than others: the *Eucalyptus* genus, including many species, and represented by the well-known *blue-gum tree* of Australia, is noted for its power in this respect; and the common sun-flower, which is very easy of cultivation, has a powerful influence in the same direction.

CHAPTER XXXI.

LOCAL CONDITIONS.

Conditions producing Climate.—Elevation.—Hill, Plain, and Valley.—Relative Elevation.—Mountain Air.—Influence of Forests.—Influence of Vegetation.—Relation of Sea to Climate.—Winds.—Moisture of the Air.—Rainfalls.—Site of a House.

The Climate of a country has an important influence on the health and character of its inhabitants.

The character of a climate depends on four main conditions:—

1. The distance from the equator.
2. The height above the sea.
3. The distance from the sea.
4. The prevailing winds.

There are other conditions which are of subsidiary importance, but which have great influence in modifying the climate of any given locality. Thus:—

5. The nature of a surface—its aspect, shelter, slope; the colour of the soil or rock, the reflection from rocks or sheets of water, and the influence of vegetation.

6. The cultivation of the soil.

7. The drainage of marshes and damp soils.

8. The planting and clearing away of forests.

The Distance from the Equator is the most important factor in relation to climate. The sun's rays become less powerful as they fall more obliquely, in travelling from the equator. This primary factor in producing climate is largely modified, however, by the relative distribution of land and water, and by the character of the prevailing winds of a district.

The Elevation of a locality has an important influence on its temperature, the temperature falling as the height is increased. The amount of fall varies with the latitude of the place, with its situation in regard to surrounding districts, the degree of moisture of the air, the presence of winds, the hour of day, and the season of the

year. It is usual to allow 1° Fahr. for every 300 feet of ascent above the level of the sea.

Hills, Plain, and Valley.—The law of decrease of temperature with increase of altitude, is liable to great modifications, and even subversions from various causes. The chief cause producing such modification of the law is the *relative elevation to the surrounding district.* Thus, in the case of rising ground, the higher parts become rapidly cooled by radiation. The air here is likewise cooled by contact, and becoming heavier in consequence, flows down to low-lying ground. It follows that places on rising ground are never exposed to the full intensity of frosts at night. A familiar proof of this is the frosting of potatoes at the bottom of a valley, and not on its slope.

Valleys surrounded by hills and high grounds, not only retain their own cold and heavy air, but serve as reservoirs for the cold air falling from neighbouring heights. One finds, in consequence, mists in low situations, while adjoining eminences are quite clear. Swiss villages are generally built on eminences rising out of the side of a mountain, with ravines on both sides of them, thus escaping to a large extent the downward currents of cold air, and the colder air at the bottom of the valley. In ascending the slope, of a hill, the increased warmth can often be readily felt.

The **air of mountains** is (1) cooler than that of lower districts with the exception already named. (2) It is less dense in proportion to the altitude ; its pressure at the height of 16,000 feet being only half that at the sea level. (3) Its absolute humidity is decidedly diminished ; there is some difference of opinion as to the relative humidity. (4) The air is as a rule purer. It is generally free from dust, and to a large extent aseptic (that is, free from the agencies which produce putrefactive changes). (5) the amount of ozone is commonly greater than in lower regions. In addition to these characters, (6) the light is intense, and (7) the direct heat of the sun is greater, and the difference between sun and shade greater than in lower regions.

Owing to these peculiarities of mountain air, it is of great value as a restorative. The *skin* receives more blood than usual; its nutrition is increased, and the tendency to catarrhs diminished. The contractions of the *heart* increase in frequency at first; soon they resume the normal rate, but are increased in force. At very high elevations there is a tendency to hæmorrhage in weakly people, especially from the lungs. The *lungs* probably receive a larger quantity of blood owing to the diminished atmospheric pressure and increased evaporation. The result is, if this effect is not excessive, that the nutrition of the lungs is improved; and if the stay at high elevations be prolonged, there is an increase in the size of the chest. The appetite is also increased, and the general nutrition favoured.

The presence of *forests* and *sheets of water* counteracts the effects of radiation from the earth. Thus if a deep lake fills the basin of a valley, the cold air descending from higher levels, cools the surface-water, which sinks and is replaced by warmer water from below. In this way deep lakes are sources of heat in winter, and places on their shores are free from the severe frosts which are peculiar to other low-lying situations.

If the slopes of a hill are covered with trees the temperature of its sides and base are considerably increased, as the trees obstruct the descending currents of cold air. The frosts of winter are felt most severely in localities where the slopes above them are destitute of vegetation, and especially of trees. It follows that in any given locality, the best protection against the winter cold is ensured by a dwelling situated on a slope a little above the plain or valley from which it rises, with a southern exposure, and sheltered by trees planted above it. Such local conditions should always be carefully enquired into, when a choice of site is possible, as the temperature of one part of a neighbourhood may differ by several degrees from that of another part near at hand. This is particularly important in the case of invalids, as in England a large

proportion of the deaths occurring in the winter months, are either due to or hastened by a low temperature.

Forests tend to modify a climate, and mitigate its extremes, whether situated on the slopes of mountains or on plains. Trees are heated and cooled by radiation like other bodies, but from their slow conducting power, the periods of their maximum and minimum temperatures are not reached for some hours after the same phases of the temperature of the air, and the effects of radiation are not confined to a small surface on the soil, but distributed to the level of the tree-tops. For these reasons, trees make night warmer and day cooler, thus giving to forest districts something of the character of an island climate. Evaporation occurs slowly from the damp soil beneath trees, as it is screened from the sun, and the trees prevent a free circulation of wind. Hence the relative humidity and rain-fall are increased.

Ground Covered with Vegetation has a more uniform temperature than bare soil, the effect being much the same as that of forests, though on a smaller scale.

All growing vegetation evaporates a large quantity of water. A plant evaporates 200 pounds of water while it forms one pound of woody fibre; the effect of a forest must, therefore, be enormous. At the same time, vegetation, and especially trees, retain moisture in the soil. The water-supply of barren regions may be greatly increased by planting trees.

The absence of vegetation leads to extreme fluctuations of temperature. An extent of sand, for instance, raises the temperature of the air greatly during the day, as it is a bad conductor; but at night, radiation is very great, and the temperature falls accordingly. The alternations of heat and cold are further intensified by the extreme dryness of the air of sand deserts.

Relation of Sea to Climate.—Water has the greatest specific heat of any known substance, being four times greater than that of the earth's crust. On this account it takes longer to heat and to cool than the earth. Unlike the earth, likewise, it allows free

penetration of the sun's rays,—in clear water probably to a depth of at least 600 feet; consequently, the surface of the water becomes less rapidly heated. The freezing point of fresh water is 32°, while that of sea-water is 27·5°—28·4°. Thus, the sea remains open at a temperature at which inland lakes freeze, and has, therefore, a greater influence in moderating winter cold and summer heat. Another factor rendering it more competent to mitigate extremes of temperature than lakes, is the presence of currents, causing admixture of the water of different climates. Deep water, wherever found, has the same influence on the atmosphere. In summer it cools it, and in winter increases its temperature. Cold water descends to the bottom of the sheet of water, and is there somewhat warmed by the deep lying, and therefore warmer, earth.

It is important to distinguish between the *surface* temperature and the *deep-sea* temperature, the latter being fairly constant. The whole of the depths of the sea is filled with water at or near 32° Fahr., which in the tropics is 40°—50° below the temperature of the surface-water.

The influence of seas on climate is so great as to lead to a classification of climates into oceanic, insular, and continental.

An *oceanic climate* is least liable to violent changes of temperature; and for this and other reasons is very valuable in the treatment of chest complaints. It can only be obtained by a sea-voyage.

An *insular climate* presents smaller differences between the temperature of summer and winter than in the interior of great continents, especially when the island is small and in the midst of the ocean. In the British Islands, the prevailing winds being westerly, places on the east coast are less truly insular than similarly situated ones on the west coast; and their climate approaches more nearly that of inland countries.

A *continental climate* is drier and more subject to extreme alternations of temperature than insular and oceanic climates.

Winds are due to differences in atmospheric pressure. Inasmuch as the temperature and degree of moisture of air depend on the prevailing winds, their consideration becomes very important. Winds bring with them the temperature of the air they have traversed: thus, in England, south winds are warm, while north winds are cold. Winds coming over an ocean cause less variation in temperature than those which have passed over an extensive tract of country. Thus, moist ocean winds are accompanied by a mild winter and cool summer, while dry continental winds cause the reverse conditions. The amount of moisture capable of being carried by a current of air increases with its temperature; therefore, equatorial winds become moister as they proceed, while north winds become drier. The south-west winds, in the British Isles, being both oceanic and equatorial, are very moist, while the north-east winds, being both northerly and continental, are peculiarly dry and parching.

Owing to the atmosphere pressure diminishing from the south of Europe northwards to Iceland, south-west winds are the most prevalent in Great Britain; and as this diminution of atmospheric pressure is greatest in the winter months, south-west winds are most common at this season. The result is that the temperature of these islands is higher than that due to mere latitude, averaging 39° in Shetland and 38° in London, instead of 3° and 17° respectively, which it would be if only latitude were concerned. As the temperature on the west coast is fairly uniform from Shetland to Wales, there is no advantage for invalids in going south, unless they go to the south-west coast.

Mountain ranges have an important bearing in determining the character of the prevailing winds. If the range is perpendicular to the direction of the winds, the latter lose the greater part of their moisture, and the places to leeward being exposed more completely to solar and terrestrial radiation (from comparative absence of aqueous vapour), winter becomes colder and summer hotter. The difference between the climates of the west and east parts of Great

Britain is largely due to this cause. In Ireland, the mountains are not grouped in ranges running north and south, but in isolated masses, and the difference in climate between the east and west coasts is consequently less marked.

The **prevailing winds** have a great **influence on the rainfall.** (1) Thus if a wind has traversed a considerable extent of ocean, the rainfall is moderately large. (2) If a wind reaches into a colder region, its saturation point is lowered, and the rainfall is greatly increased; and if a range of mountains lies across its path, the rainfall on the side facing the wind is greatly increased, but diminished on the opposite side of the range. (3) If a wind after reaching land proceeds into lower latitudes or warmer regions, the rainfall is small, or absent. This accounts for the rainless summers of California, North Africa, and South Europe.

The **Moisture of the Air** depends upon the amount of vapour present in it, and the ratio of this to the amount which would saturate the air at the actual temperature. The former is called the *absolute humidity*, the latter the *relative humidity*. The *dew point* is the point at which condensation of some of the vapour in the atmosphere occurs, either as dew, rain, snow, or hoar-frost. The amount of moisture which the atmosphere can retain before such condensation occurs, varies with the temperature. If the temperature is low, the dew point is speedily reached; while, if the temperature is high, the same amount of moisture may be present, and yet the atmosphere appear dry and oppressive. Thus the air is drier at noon than at midnight, though the amount of vapour present in the two cases be the same; and it is for the most part drier in summer than in winter. This refers to the relative humidity, which is highest in cold weather. The absolute humidity is higher in summer than winter; it varies more in continental than in maritime and insular climates; and there are daily variations according to the state of the sky, the movements of air, etc. The relative humidity is expressed as a per-centage of what would be required to produce saturation at the given temperature. The usual

relative humidity is 50 to 75 per cent. If the air were constantly near the point of saturation, clouds which consist of drops of water, would obey gravity, and descend as rain more frequently than they do. The reason why rain is not constantly falling is that there is usually a non-saturated region between the clouds and the earth.

The Rainfall is caused by over saturation of a column of moist air. This may be due to the contact of the air with a cold surface, as the ridge of a mountain or a large surface of water, or to the impact of a colder wind.

The amount of rainfall varies greatly. In some parts there is no rain, as in the desert of Sahara; while on the south-east slopes of the Himalayas, which are exposed to winds laden with moisture, it may be several hundred inches.

The amount of rainfall does not depend on the absolute humidity of the air. In Lima on the coast of Peru, there is no rain although the air is moist; while in the gulf of Genoa there is a considerable rainfall with a moderately dry air and soil; the difference being due to the presence of cold winds in the latter case (increasing the relative humidity).

The *latitude* of a place has a great influence. As a rule the rainfall decreases with increasing distance from the equator; but local conditions may produce great modification, or even alterations of this law.

The *elevation above the sea-level* has a varying influence. In the Swiss Alps it is said that the rainfall increases with the elevation; but this rule does not hold good in America.

The *nearness of large surfaces of water* in summer tends to increase the rainfall, when water is colder than its surroundings, while in winter it has the opposite effect. The neighbourhood of the sea is for the west of England and islands adjacent, a cause of increased rainfall.

The *influence of winds* on the rainfall has been already considered. In Great Britain south-west winds more especially increase the rainfall. In their course they have travelled over the Gulf

Stream and the general equatorial current, and have thus received warmth and moisture. The condensation of their moisture liberates a large amount of latent heat, thus raising the temperature of this country. In summer, however, south-west winds are *cool* and moist, as the Atlantic is not so hot as the continents of Asia and Europe over which other winds have travelled.

In England the average rainfall is 30—32 inches, but there are great variations in different parts. In the west of Great Britain and Ireland, and near hills, the average rainfall is over seventy-five inches. In the east of Great Britain, the rainfall is from twenty to twenty-eight inches. The average rainfall must not be relied upon entirely. In this country it has been estimated that the maximum annual rainfall exceeds by one-third, and the minimum annual rainfall is less by one-third than, the average rainfall of a series of years.

The *number of rainy days* by no means corresponds with the amount of rainfall. On the contrary, there are fewest rainy days at the equator, where the rainfall is greatest. A considerable rainfall by no means renders a place undesirable as a health-resort, if it does not prevent out-door exercise. The rain diminishes the relative humidity of the air, and purifies it from dust.

A certain amount of moisture in the air is essential to both animal and vegetable life. It moderates the heat of the sun's rays, and prevents excessive radiation from the earth's surface, absorbing the heat rays as they leave the earth. Thus, the moist air forms a warm garment in which the earth is enclosed.

The amount of absolute moisture in air has an important influence on respiration. The inhalation of a dry air increases the loss of water vapour through the breath, and thus diminishes or checks perspiration. A dry climate is, therefore, an important part of the treatment of consumption and certain cases of bronchitis.

The degree of relative moisture exerts great influence on the functions of the skin. If the skin is moist, the amount of

evaporation from the skin is diminished. A feeling of oppression results, the tissue changes are diminished, and there is a disinclination for work. Much of the exhilarating effect of a mountain atmosphere is due to its dryness during the day, though its rarity and purity have much to do with the effect produced.

Site of a House.—It will be convenient to recapitulate under this head the local conditions to be considered in the choice of a house.

1. The *Aspect* should be such as to allow the free approach of both air and sun. Light is essential to health; it is important, therefore, that the house should not be hemmed in closely by surrounding buildings, walls, or trees, and that the windows should be large and numerous. Taking all seasons of the year, a southerly or south-westerly aspect receives most sunshine; an easterly receiving very little. As Mr. E. Turner puts it:—"A *northerly* aspect is always bleak and cold, and almost always damp. An *easterly* aspect is cold, especially in the spring; but it is fairly dry, though a good deal of rainy weather comes at times from the south-east. A *southerly* aspect combines as much of warmth, dryness, and sunshine as the peculiarities of the climate will in any way allow. A *westerly* aspect is warm, but inclining to damp, and exposed to the most boisterous and rainy gales which, especially on the Channel coast, come almost always from the south-west."

A workroom or study requiring steady light, should point north or some point between north-east and north-west. A breakfast room should face north-east to south; while one aspect of a drawing-room should be south-east to north-east. Rooms requiring coolness, as store-rooms, dairies, larders, should have a northerly aspect.

Invalids should avoid the north and east sides of a house. It is preferable, as a rule, for the house not to face in the direction of the four points of the compass, but diagonally to these, as thus extremes of heat and cold are mitigated.

2. *The influence of surrounding objects.*—The neighbourhood of cesspools and middens is to be specially avoided. If the house is

one of a number, and especially if it is at a lower level than others, it is important to ascertain that its drainage relationships to other houses are satisfactory.

The influence of *trees* close to a house is bad. They render it damp, and prevent the free access of sun and air. If the trees are somewhat removed from the house, they form a useful shelter, especially when to the north or east.

The neighbourhood of *water-courses* of any kind is to be avoided, it is apt to be damp. If the house must be on a plain, its site cannot be over-drained. If there is a choice, the *slope of a hill* should be selected; and it is essential that the building be kept clear of ground at a higher level. This is secured by raising the site, so that the surface slopes down from the house towards the rising ground. High positions are not always free from the dangers of valleys, as winds may waft marshy effluvia several miles. It often happens that a low-lying district near a marsh, if protected by a screen of wood, is safer than a higher part lying to leeward.

Ground covered with rank vegetation is to be avoided, because of the amount of decaying matter in the soil, and because such vegetation generally indicates the presence of much sub-soil water.

3. The *Soil* has an important influence on the healthiness of a site. The relative merits of the different kinds of soil have been already discussed. Undrained soils of whatever kind are bad, and made-soils are always to be regarded with profound distrust.

CHAPTER XXXII.

PERSONAL HYGIENE.

Influence of Constitution, Heredity, Idiosyncrasy, Temperament, Sex, Age, and Habits on Health.—Attention to the Action of the Bowels.

There are certain personal factors which are very important in relation to health. The chief of these are constitution, temperament, heredity, idiosyncrasy, age, sex, and habits. We will consider each of them in turn.

Constitution.—Health may vary in degree without the presence of actual disease. This fact is expressed by the use of such terms as "perfect," "strong," "feeble," "delicate," in speaking of the health of the same person at different times, and also as distinguishing one individual from another. The constitution is an important factor in resisting disease, and a robust constitution may determine recovery from a severe illness, while the patient with a feeble constitution falls a victim to it.

The constitution of an individual is either *acquired or inherited.* A feeble or delicate constitution is frequently acquired by unhygienic conditions, such as deficient exercise, the prolonged breathing of impure air, unhealthy occupations, some imperfection in diet, or dissipation.

But while many a robust constitution is enfeebled by such conditions, a weak constitution may happily be strengthened by careful and prolonged attention to the laws of health. This is especially well seen in the case of those who strengthen their muscular system by carefully-graduated and not excessive exercise.

Heredity has a great influence on health. As a rule the children of healthy parents are robust, and on the contrary, any "weak point" in the parents' constitutions is liable to be participated in by their children. Both *mental* and *physical* conditions may be inherited. A peculiar habit of mind, as well as the same expression of features, is commonly hereditary. So also is the tendency to excel in certain directions. This was well seen in the case of a compositor, who had acquired his art after considerable trouble, while his daughter subsequently was able to read type sideways or inverted without any tuition at all.

As regards physical diseases, the influence of parents is not less remarkable. The son of a gouty father requires to be particularly abstemious in order to avoid his father's disease. Rheumatic fever and St. Vitus' dance, again, are commonly hereditary. Insanity, epilepsy, asthma, neuralgia, and hysteria are also hereditary, and it is noticed that they often alternate ; thus an epileptic parent may

have an insane or asthmatical child. Cancer, consumption, certain skin diseases, and a tendency to the early onset of degenerative diseases, are also hereditary.

It is important to note that in most cases it is usually the tendency to disease which is transmitted, and not the disease itself.

All these diseases may be acquired without any hereditary tendency. Thus, consumption is very common among compositors, owing probably to the bad air and constrained position in which they work. Gout is often acquired by painters, through the influence of lead-poisoning. Again, hereditary tendencies may be eradicated by careful attention to the laws of health. Thus, by an abundant supply of fresh air, by moderate exercise, and the avoidance of severe colds, even the offspring of consumptive parents may escape that disease.

A peculiarity of form, character, or tendency to disease has been known to disappear in one generation and re-appear in the next; this variety of heredity is termed *atavism*.

Temperament is a word somewhat lacking in precision, but embodying a useful generalisation. It indicates a peculiarity in constitution, causing a liability to particular diseases, or to a special character in any disease to which a person becomes subject. Four temperaments are usually recognised—the sanguine, phlegmatic, bilious, and nervous.

The *sanguine* temperament generally manifests itself by a fair complexion, active circulation, quick movements, and excitable passions.

The *phlegmatic* temperament (or lymphatic) is distinguished by a languid circulation, a pale face wanting in character and expression, and a tendency to general torpor of mental and bodily functions.

The *bilious* temperament is generally accompanied by strongly-marked features, dark hair, and swarthy complexion. The circulation is stong, but not easily excited; and there is great power of mental and physical endurance. If there is mental depression with it, it is called a *melancholic* temperament.

The *nervous* temperament is characterised by a spare form and small muscles. The features are delicate, the complexion pale or slightly red, the pulse quick and easily excited, the senses acute and the imagination lively.

Pure specimens of these temperaments are rarely seen; more often they are mixed, and it may be difficult or impossible to say in any given case, which temperament is most prominent. The above classification (which is the same as that described by Dr. Guy) is somewhat artificial, and is only useful as indicating certain differences in the character and physique of individuals.

Idiosyncrasy.—By idiosyncrasy is understood a peculiarity limited to a comparatively small number of individuals. It means that certain persons are specially sensitive to the action of certain things, or are peculiarly affected by them. Four varieties of idiosyncrasy may be described.

The first consists in an extreme susceptibility to the action of certain things, or an extreme lack of susceptibility. Thus most people at some time or other inhale the pollen of grasses, but only in a few cases does it produce that troublesome and distressing complaint—hay asthma. In certain persons a very minute dose of iodide of potassium produces distressing symptoms; in most cases these symptoms arise if the drug is taken for a prolonged period; but in a few cases it may be taken for an indefinite period without troublesome result. The case of a well-known physician at Bath is very curious. The smell of hyacinths in bloom always made him faint away; so constant was this result, that before entering a room during the hyacinth season, he always asked the servant if there were any hyacinths in it.

The second form of idiosyncrasy consists in the production of poisonous results by common articles of diet. Thus some people cannot partake of shell-fish or lobsters without having severe nettle-rash. In rare instances the smallest amount of egg, or in other cases mutton, or pepper, or some other substance will produce severe indigestion or nettlerash.

The third form consists in an inversion of the usual effects of certain substances, especially drugs. Thus opium in rare cases produces convulsions; while the aperient Epsom salts have been known to produce constipation.

A fourth form, that of mental idiosyncrasies, may be added, as where there is a strange preference or aversion for objects usually regarded as indifferent. Many cases of mental peculiarity, short of actual insanity, will come under this head; as will instances of depraved appetite for food, etc.

It may be well to mention at this point the tendencies to disease which most people have peculiar to themselves. Each person commonly has a "weak point" in his constitution; and so it comes to pass that the "cold" which in one would produce a sore throat, in another leads to bronchitis, and in another to acute rheumatism.

Age and Sex.—According to the period of life, danger arises from different sources. In *infancy* and old age extreme changes of temperature are especially dangerous, and additional protection is required. Thousands of deaths occur in the first year of life, from substituting starchy foods for milk, the natural food of infancy and childhood. In *childhood* the danger from bad feeding is still present, and is evidenced by the frequency of the bowed legs and great misshapen heads, due to rickets; infectious diseases claim their thousands; and dentition (teething) is a frequent source of irritation and disorder. In *youth* rapid growth is proceeding, and so the food must be abundant and nutritious. A proportionately larger amount is required than by an adult, as the functions of the body not only require to be carried on, but material is necessary to build up the growing tissues. The effects of over-pressure in school work at this period are especially to be lamented; and these effects will doubtless be felt more severely in board schools, where the boys who are badly fed and clad are expected to learn as much—involving an equal expenditure of force—as their more fortunate comrades. The result of this over-pressure if continued must inevitably be a deterioration in the physique of the working classes.

In *manhood* the constitution is supposed to be established, and this is the period of greatest stability of health. The health now depends on the use made of the previous periods of life, and on the habits acquired.

With the onset of *old age* come various weaknesses called degenerative diseases. The tendency is to death by gradual decay—a *euthanasia* or easy death, which is far too seldom seen. Commonly, bronchitis, or apoplexy, or kidney disease bring the scene to a somewhat permature end.

The mortality of man is greater than that of woman at nearly all ages. This difference is seen even in childhood, the mortality in children under five years old being at the rate of 73 boys and 63 girls per 1,000.

Habits.—The immense power of habits in the formation of character is perhaps duly appreciated; but their influence on physical health is not so well appreciated, though it would be difficult to exaggerate it. The lamentable lack of knowledge of Physiology is to a large extent the cause of the many unhygienic habits which are fruitful in disease.

The laws of health are as inexorable and unaltering as all other laws of nature; and whether broken through carelessness or ignorance, the Nemesis of disease inevitably follows. Whatever a man sows he reaps, in health as in other matters.

Habits are easily formed; but, when once formed, not so easily broken. They ought to be our servants; very commonly they become our masters.

In reference to *eating and drinking*, habits regular as to time and moderate as to quantity are especially important. The habit of eating hastily and masticating the food imperfectly, is certain, sooner or later, to produce disease. Over-eating, again, is a fertile source of disease, especially when the excess is in animal food. The importance of good habits, in reference to alcoholic drinks, is very great where wine, etc., are taken for their stimulating effects. The amount of stimulation produced by a given dose of

alcohol, gradually diminishes with its repetition; the consequence is, that in order to produce the amount of stimulation to which the system has become habituated, the stimulant requires to be gradually increased. Persons of finely-organised nervous temperaments are much more liable to acquire habits of alcoholic excess than others, though they by no means enjoy a monopoly in alcoholism. The craving for stimulants is often a sign of ill-health, owing to disregard of hygienic laws or actual disease. Not unfrequently it is due to a badly-ventilated room, or long hours of work without food, producing a sense of depression which food does not immediately allay. When the cause is unknown, recourse should be had to competent medical advice, and not to the brandy bottle.

Attention to the Action of the Bowels is a matter which is commonly neglected. The importance of a regular habit in this respect cannot be exaggerated; the bowels should always be relieved at a particular part of each day. Where this does not occur the condition of *constipation* results. Owing to the retention of the fæces in the intestines beyond the normal period, the stomach and higher parts of the intestines do not perform their functions normally; indigestion is the consequence, accompanied by flatulence, a sallow complexion, and a tendency to "biliousness." Hæmorrhoids (piles) are another frequent consequence. At the junction of the small and large intestines is a dilated sac (in the cæcum), and the fæces tend especially to collect at this point, when constipation occurs; consequent on this, inflammation is set up, and sometimes perforation of the bowel, with a fatal result. The effect of purgative medicines on constipation is only temporary, and they usually leave the intestines in a worse condition than before, and less able to contract on and expel their contents. It is better to take slowly-acting purgatives than violent ones, and better still not to take any at all, but relieve the condition by means of such articles of diet as stewed fruit, pears, figs, olive oil, or brown bread. As a rule more exercise is required in this condition, and always a prompt attention to the calls of nature.

CHAPTER XXXIII.

PERSONAL HYGIENE (*continued*)—EXERCISE.

The Physiology of Exercise.—Effects of Healthy Exercise on the Various Organs.—Effects of Excessive Exercise.—Amount of Exercise Desirable.—Effects of Deficient Exercise.—Rules Respecting Exercise.—The Forms of Exercise.

Physiological Considerations.—In the strict sense of the word, exercise signifies the performance of its function by any part of the body; thus, digestion is exercise of the stomach, respiration is exercise of the lungs, thinking is an exercise of the brain. But the term has become restricted in its application, and now is chiefly applied to muscular contraction—the exercise of the muscles of the body. Here, again, there has been a restriction of the term exercise in the ordinary sense, to the contraction of voluntary muscles, those under the control of the will. Involuntary muscles, which are concerned in the carrying on of the unconscious organic functions of life, are not directly controllable, and so their growth and state of nutrition cannot be regulated. There are two sets of involuntary muscle, which are of special importance—the heart and the muscles of respiration. The heart contracts—that is, it is exercised — at least sixty times per minute; the respiratory muscles contract about seventeen times per minute; and this amount of exercise goes on throughout the whole day. But although we cannot make our hearts beat quicker by a direct volition, and cannot breathe more rapidly than usual beyond a few seconds, yet a brisk walk will cause increased action of the heart and respiratory muscles, as well as a vigorous contraction of the muscles directly concerned in walking. And there can be no doubt that the vermicular contractions of the intestines are to some extent increased by voluntary exercise, through the indirect excitation of the whole system; thus, exercise is an important element in the treatment of constipation.

The muscles are estimated to contain about a fourth of the whole

blood of the body. Even during muscular rest (so far as this is possible, for nearly every posture involves the exercise of certain muscles), the ultimate molecules of which muscle is composed become oxidised to a certain extent. By exercise this oxidation or combustion is increased. To live is to oxidise; to exercise is to oxidise more actively. It is necessary for the health of the body that the molecules of which it consists should be disintegrated and die, to be replaced at frequent intervals by new materials from the blood. The strength of the body, and of every part of it, is in proportion to the activity of its nutritive changes. In the same proportion as disintegration is hastened by muscular activity, so always is the flow of blood bearing the renewing material. Thus, active exercise, if not excessive, increases the action of the heart, and so strengthens this organ likewise.

It is a common fallacy to suppose that exercise wears out the human machinery, just as it will wear out any piece of human mechanism. On the contrary, it increases the working power of the muscles, owing to the self-renewing powers they possess.

During the period of growth, that is, up to the age of about twenty-five, the new materials added to a muscle when it is exercised exceed the old, and so a gradual increase in bulk and power occurs; even after this age the same may occur, owing to the fact that very few attain to the normal development of their muscular powers in the earlier part of their lives.

The same rules as for muscular exercise apply to brain exercise. The more the brain is exercised,—if proper intervals of rest are allowed, and the muscular development is not allowed to lag behind,—the more perfectly the brain will perform its functions. The powers of memory, observation, judgment, speech, etc., may be greatly increased by careful cultivation and persistent attention. The great danger is of not equilibrating the muscular and nervous functions. One sees a nervous, excitable boy with overwrought brain, feeble muscles, and a tendency to premature decay; or a young athlete whose mental powers are

far from vigorous. The ideal condition is where neither mental nor muscular culture is neglected, but both are co-ordinated to the production of a perfect man.

Effects of Healthy Exercise.—1. *The Nutrition of the Muscles* is improved by exercise. The blood which they contain is increased, and in consequence of this increased afflux of blood and the more rapid disintegration going on in the muscles, they become harder and larger, and respond more readily to the commands of the will. In other words, the volume, density, and energy of the muscles are increased.

2. *The action of the lungs is increased by exercise.* Dr. E. Smith found that if the air inspired while lying down be represented by unity, the amount inspired when erect is 1·33; when walking at the rate of one mile per hour, 1·9; at four miles per hour, 5; at six miles per hour, 7; riding on horseback, 4·05; swimming, 4·33. Or, putting it in another way, under ordinary circumstances a man inspires 480 cubic inches per minute; if he walks four miles an hour, he inspires 2,400 cubic inches; if six miles an hour, 3,260 cubic inches.

At the same time the amount of carbonic acid gas expired is correspondingly increased. Its amount bears a nearly constant relation to the amount of muscular exercise, and consequently the amount of carbonic acid eliminated in various forms of exercise affords a just estimate of their relative value. If the carbonic acid resulting from respiration is not quickly got rid of, as in ill-ventilated warehouses and shops, especially where the work is severe, the substance of the muscles soon becomes loaded with carbonic acid, and their activity diminished. For this reason, if for no other, it would be economical for large employers to provide an abundant supply of fresh air to their workpeople.

Besides the presence of abundant oxygen (from the air), and an easy and complete riddance of the carbonic acid produced by muscular exertion, it will be evident that a third factor is required in the performance of muscular exercise, viz., a supply of carbon:

this is obtained from the assimilated food, brought to the muscles by means of the blood.

Fatty food supplies the necessary combustible material more perfectly than amylaceous (starchy) and saccharine (sugary) foods. Alcohol diminishes the excretion of carbonic acid, and should therefore be avoided during muscular training.

Not only does muscular exercise increase the activity of respiration, but the size of the lungs is increased, and their *vital capacity*, that is, the amount of air capable of being expired after a forced inspiration, is considerably increased. Corresponding with this increase of vital capacity, exercise, especially that in which the arm and chest muscles are systematically developed, increases the size of the chest. A perceptible difference in the circumference of the chest may be noticed after only a few weeks' methodical exercise.

3. *The action of the skin is increased.*—Sensible perspiration is commonly induced, but less readily in those habituated to hard work. Insensible perspiration is always increased, the amount of water escaping in a gaseous condition being at least doubled during moderate exercise.

4. *The temperature of the body* is not perceptibly increased, so long as the skin continues to act. Every muscular contraction involving oxidation also necessitates the production of heat; but this is counteracted by increased evaporation from the skin, and by the circulatory current carrying the hotter blood to every part of the body, and so rapidly equalising its temperature. But although the actual temperature is not increased, it is rendered more equable owing to the increased force of the heart's contractions. Chilblains are due to the defective circulation of the blood, and can in most cases be cured by active exercise aided by warmer clothing and an abundant supply of oxidisable food.

5. *The Heart and Blood-vessels.*—By exercise the heart's action is increased in frequency and force. The pulse usually increases from ten to thirty beats per minute above the rate while at rest.

After prolonged exercise it may temporarily fall below the normal standard.

6. *The digestive system* is aided indirectly, though active exercise impedes digestion. Following exercise, one has an increased appetite, especially for fatty and nitrogenous food; digestion becomes more perfect, and absorption of food is more rapid, owing to the loss of water by the skin. The effect of exercise on appetite and digestive power is greater if the exercise is taken in the open air; and outdoor exercise is in this way a valuable aid in the treatment of indigestion.

7. *The nervous system* is improved in nutrition and power by a moderate amount of exercise. In fact, a certain amount of muscular exercise is essential for a healthy mind. The intellect is only made less active by excessive exercise; and in this case it is probably because no time is devoted to mental culture, rather than in consequence of any direct effect of excessive muscular exercise on the brain.

8. *The elimination of urea* has important bearings on muscular exercise. Urea (CH_4N_2O) represents the ultimate stage at which nitrogenous tissues and food arrive, in their course from their entry into the body as food to their ultimate oxidation and elimination. The substance of the muscles is largely composed of nitrogenous material (myosin), and it is very interesting to note that the amount of urea excreted from the body (chiefly by the kidneys) is only slightly increased by muscular exercise. Evidently then it is not the oxidation of the nitrogenous substance of the muscles which supplies the force of muscular contraction; but the other oxidisable and non-nitrogenous substances (such as glycogen and sugar) contained in it.

The conclusion arrived at by Dr. Pavy in his investigations on Weston during a pedestrian match, was that although there was a greater elimination of urea during severe exercise than could be accounted for by the increased nitrogenous food taken, yet that the motor power did not arise from oxidation of the muscle tissue, and

that the greater part of the urea eliminated was probably derived directly from metamorphosis of nitrogenous food (which had never become built up into tissue). Thus, supposing the elimination of one grain of nitrogen (chiefly as urea) to represent $2\frac{1}{2}$ foot tons (that is, the force required to raise $2\frac{1}{2}$ tons one foot high), he calculated that the urea eliminated was only sufficient to account for one half the force expended. Therefore considerable force must have been developed from the oxidation of the non-nitrogenous substances in the muscles. These results were obtained from the investigation of excessive exercise. But other observations have proved that the urea and other nitrogenous excretions may not be at all increased, and may even be decreased by muscular exercise. Commonly it is found that the increase of elimination of urea is in the period of rest succeeding exercise. One finds practically that with moderate exercise a little more nitrogenous food is required, and with laborious work a somewhat larger quantity; but that the quantity of non-nitrogenous food requires to be increased in a somewhat larger proportion.

Effects of Excessive Exercise.—After prolonged exertion muscles become *exhausted.* This is associated with an accumulation in the muscles of the products of their action (especially sarcolactic acid), and to a less extent with exhaustion of the supply of oxygen. Then rest becomes necessary, in order that the effete products may be removed, and the reserve force of the muscles may be renovated.

Long-continued over-exertion produces *chronic exhaustion*, which may, if excessive, result in wasting of muscles. Exhaustion is much more liable to occur when a small group of muscles are exercised out of all proportion to others. Thus, in clerks, we have what is known as the *writer's* or *scrivener's palsy.* The muscles of the hand, and especially of the thumb, cease to respond to the volition of the writer, but are seized with spasm every time writing is attempted; and the muscles of the thumb tend to waste. A similar condition sometimes arises in violinists,

tailors, etc. The practical inference from these facts is, that one group of muscles should not be exercised disproportionately to the muscles of the rest of the body, and that proper intervals of rest should be allowed.

Excessive exercise of the whole muscular system is particularly pernicious when undertaken by those of previously sedentary habits. A walking tour entered on with more zeal than discretion, and not taken by easy stages for the first few days, is often productive of more harm than good. The same evil is seen in the case of volunteers camping out for certain weeks in the year, and subjecting themselves to great exertions and vicissitudes, who have at other times of the year had no preparatory training.

In the intervals of great mental labour, as with students, the amount of exercise should not be *suddenly* increased, but should be regular and moderate in amount.

Competitive exercise is not desirable, as the tendency is for the strength to be over-taxed. The Oxford and Cambridge crews have been said to acquire heart-disease more commonly than the average, but this is not correct. Doubtless hypertrophy of the heart may occur as the result of severe exercise, and this within certain limits is not an abnormal condition. In those who have a weak heart, occasionally dilatation and even rupture of the heart have been produced. The latter is, however, extremely rare,—"a broken heart" being much commoner in novels than in actual life. Aneurism, that is, a local dilatation and bulging of a blood-vessel (especially affecting the aorta), is more common among soldiers than civilians, but it is doubtful whether this is due solely to the excessive exertions which they occasionally undergo, or to this acting along with their heavy and tight accoutrements.

Sudden and severe exertion may cause rupture of some of the air-vesicles of the lung (the condition known as emphysema). A horse suffering from this condition is called "broken-winded," or "roaring," and the cause in this case is probably the same.

Amount of Exercise Desirable.—According to a careful estimate

of Dr. Parkes, the average daily work of a man engaged in manual labour in the open air is equivalent to the work involved in lifting 250 to 350 tons 1 foot high; this is a moderate amount, 400 tons being a heavy day's work. The amount of muscular exercise involved in this may be easily known by remembering that a walk of 20 miles on a level road is equivalent to about $353\frac{2}{3}$ tons lifted 1 foot; and that a walk of 10 miles while carrying 60 lbs. is equivalent to $247\frac{1}{2}$ tons lifted 1 foot. (Haughton.)

We may estimate that every healthy man ought to take an amount of exercise represented by 150 tons raised 1 foot, which is equal to the work done in walking $8\frac{1}{2}$ to 9 miles on a level road. A certain amount of this exercise is taken in performing one's daily work; but apart from this, out-door exercise should be taken equivalent in amount to a walk of five or six miles. It is impossible to lay down rules to suit all cases, but a less amount of exercise than that named is probably incompatible with perfect health.*

Effects of Deficient Exercise.—The *muscles* themselves become enfeebled and wasted; they respond less readily to one's wishes when called into use. Some wasting of muscle occurs after a few days' confinement to bed; and a limb confined in a splint speedily loses its healthy, rounded contour. The muscles of ladies' arms are usually badly developed; this is partly owing to their tight-sleeved dresses, but more to deficient muscular exercise of the arms. *Oxidation processes* are diminished; less carbonic acid is eliminated, and it tends to accumulate in the system, owing to the diminished activity of respiration. In consequence of the diminished oxidation, the temperature of the body is not well maintained, and the heat is not uniformly distributed. Cold feet are a common complaint of those who lead sedentary lives, though seldom complained of by others.

Along with the other muscles, the *heart* becomes enfeebled and the circulation less perfect. *Digestion* is enfeebled; the appetite is poor. The *nervous system* also suffers: nervous irritability is a common result, while sleeplessness—a thing almost unknown

* Problems as to exercise will be found explained at page 439.

among those who live by the sweat of their brow—is becoming much more common among the worried and ill-exercised inhabitants of our towns. As Maclaren has said, "Scholarships, examinations, speculations, excitements, stimulations, long hours of work, jaded frames, weary brains, jarring nerves, all intensified, seek in modern times for the antidote to be found alone in physical action."

There is no doubt that many diseases are favoured by deficient exercise, and can be averted by systematic exercises and the concomitant increased supply of pure air. It is often difficult to appraise the relative merits of exercise and pure air; but there can be no doubt that both are of extreme importance.

Consumption, even in those with a strong hereditary tendency, may be averted by systematic exercises, especially those directed to the expansion of the chest cavity. In most cases of consumption there is a history of deficient exercise or some constrained position, as well as of living in an impure air and on a damp soil.

Various deformities are induced by defective exercise of particular groups of muscles. Thus drooping shoulders result from shoulder-straps confining the action of the shoulder-muscles in the earlier years of life. Stooping is commonly due to sitting in cramped positions in school, and to the use of desks not inclined at the proper angle. Lateral curvature of the spine is also due to weakness of the muscles of the back, and is best treated in its earlier stages by gymnastic exercises specially directed to strengthening these muscles. The tendency to such curvatures is greatly increased in girls by the fact that their trunks are imprisoned in corsets as if in splints, and so exercise of the trunk muscles is reduced to a minimum.

Rules respecting Exercise.—1. *The clothing during exercise should not be excessive*, and should not interfere with the free play of the limbs, nor with full expansion of the chest. Flannel is the best material to wear next the skin, in case of perspiration.

2. *Avoid chill after any exercise.* Muscular rheumatism, or still

graver evils, not uncommonly result from neglect of this rule. To prevent these, it is well, if there has been any perspiration during exercise, to strip and scrub the skin, particularly about the chest and arm-pits, with a rough towel.

3. *Exercise should be systematic and regular*, not by fits and spurts. It is very important to avoid sudden, violent, and competitive exercise. No severe exercise ought to be undertaken without a gradual training.

4. *The amount of exercise must be regulated by individual fitness.* A chain is no stronger than its weakest link. The muscles may be stronger than the heart or lungs, and the latter may be fatally injured by an amount of exercise which the muscles can well bear. Hence the importance of ascertaining the condition of the vital organs before entering on a course of training.

Another important bearing of this rule is in relation to the exercise of growing boys and girls. When we remember that a boy at school will sometimes grow six to eight inches in a year, it is evident that all the available force is being expended in this direction, and that *excessive* gymnastic exercise can only do harm. Between the ages of fifteen and seventeen there is usually the greatest amount of physical development, and if there is great muscular strain at this period, growth is interfered with, or the seeds of constitutional disease are laid.

5. *Every part of the body ought to be exercised.* This is done spontaneously by the infant. Every muscle of his body acts in sheer delight. His limbs are thrown about, and so he educates the muscles attached to them, while his crowing and crying serve to exercise the muscles of respiration and speech. The evils of exercise confined to particular groups of muscles have been already described. Many of our national games exercise chiefly the muscles of the trunk and legs, while the arms are comparatively little used. Lawn tennis is very valuable as affording exercise for both limb and trunk muscles, and still more so as it is a form of exercise which ladies adopt.

6. *Exercise should not be taken immediately after meals,* as thus digestion is interfered with.

7. *Exercise should be taken, as far as possible, in the open air.* A small amount of exercise out of doors is much more invigorating than a larger amount indoors. The benefit of gymnastics for girls is greatly diminished by their being commonly taken in closed rooms. This is a fact commonly lost sight of, though its importance is very great.

The Forms of Exercise taken may be divided into *recreative* and *educational,* though both of course may be recreative under many circumstances.

The primarily recreative exercises, such as rowing, cricket, football, etc., chiefly exercise the lower half of the body, with sometimes the addition of the muscles of the right arm. Educational gymnastics can be applied to exercise the muscles of any part of the body, and can be exactly graduated to individual requirements. Both forms of exercise are valuable, and should be encouraged.

Singing, speaking, and reading aloud, are forms of muscular exercise very much neglected, and they are particularly important, as the lungs and voice are by these means greatly strengthened, and rendered much less liable to the inroads of disease.

CHAPTER XXXIV.

PERSONAL HYGIENE (*continued*)—REST AND SLEEP.

The Physiology of Rest.—Partial and General Rest.—Sleep.—Practial Rules respecting Sleep.—Sleeplessness.

Physiological Considerations.—Life is made up of alternations of rest and action. The exercise of any organ is followed by a necessary period of repose, during which the oxidised materials produced by functional activity are removed by the blood, and carried to the excretory organs; while at the same time fresh

nutritive material is supplied by the blood to make good the losses thus sustained. Not only is there during rest a storing up of tissue-food brought by the blood, but if the rest be duly proportioned to the amount of exercise, a certain amount of reserve force is also stored up, ready for any extra emergency.

The only apparent exceptions to this rule of alternation of rest and exercise are the heart and lungs, and some less important organs acting out of the control of personal volition. But even these organs obey the universal law. The difference is that their rest is very frequent and momentary; the heart having to contract sixty or seventy times per minute, rest $\frac{6}{11}$ of a second each second, or more than thirteen hours in the twenty-four. The lungs and respiratory muscles rest a shorter time than this, but probably about three hours per day.

The necessity for rest is well shown by the sense of taste. If salt is kept in the mouth for a considerable time, the power of tasting it disappears, and only returns in its original strength after several hours. The gustatory nerve has been exhausted.

The other sense-organs illustrate the same principle. Persons are not uncommonly made deaf by the deadening sounds of machinery. The same principle is illustrated by the advertisement of a well-known soap. After looking at a particular colour for some time, the nerves receiving impressions from this colour are exhausted, and only its complementary colour is visible. The importance of rest is even greater in the case of the brain and the muscles.

Rest may be either *partial* or *general.*

The principle of partial rest has very useful practical bearings. Such rest is illustrated by the student who takes a walk, or uses methodical gymnastic exercises: a concert may provide agreeable exercise for the auditory nerves and the part of the brain connected with them, while allowing the over-tired intellectual part of the brain to rest in peace; similarly, light literature may prove a pleasing rest after severer studies.

Walking is more especially the exercise of the brain-worker.

By it a larger amount of blood is determined to the muscles, and in accordance with this one finds the difficulty of carrying on any discussion requiring serious thought during an active walk.

Partial rest is the same thing as *change of occupation*, and by a careful regulation of the relative amount of cerebral and muscular work, one can economise one's powers to a very great extent. The horse, which exercises chiefly his muscles, requires only five or six hours to recuperate his force; and our muscles require less sleep than our brain. It is evident from this that in order to economise the amount of sleep necessary for the maintenance of health, muscular ought to be in excess of cerebral work. The student requires much more sleep than the labourer; if he obtains a proper amount of sleep for his brain, this is too much for his muscles —indeed far too much, reckoning their comparative inactivity during his waking hours.

Sleep is the only form of complete and general rest. In attaining this condition, the muscles sleep first, then the eyes close (owing to muscular rest), and the thoughts wander; hearing is the last sense to lose cognizance of the surrounding world; dreaming succeeds wandering thoughts, and even dreaming may cease if the brain repose is complete.

During sleep the brain diminishes in size, and becomes paler; in other words, there is cerebral anæmia, or diminution in the amount of blood in the brain. That sleep and cerebral anæmia are closely related to each other is, to some extent, shown by the fact that pressure on the carotids will produce sleep; but that this is not the only factor is evident from the fact that if nitrite of amyl (a drug producing an extra flow of blood to the brain) be inhaled by a person asleep, he does not wake up in consequence. It is probable that the cerebral anæmia is rather a consequence of the functional inactivity of the brain during sleep than a cause of the sleep.

It was formerly thought that sleep is produced by cerebral congestion—that is an increased flow of blood to the brain. But

cerebral congestion produces a stupified and unnatural sleep, the same sort of sleep as is produced by an excess of stimulants.

During sleep certain organs still continue to perform their functions. The heart and lungs continue their work; the blood is circulated and purified, the intestines continue their vermicular contractions, and absorb food from the alimentary canal, and the organs nourish themselves at leisure and reconstruct their tissues.

It is necessary to remember two facts in relation to sleep, which have important practical bearings. First, that during sleep *combustion is less active*, and so the temperature of the body tends to be somewhat lowered. Secondly, that *assimilation is more energetic;* this favours the absorption of noxious vapours, if any are present. There is less danger of remaining in a stuffy, impure atmosphere during the day than during the night—though, judging by the ordinary condition of bed-rooms, one would imagine that exactly the opposite was the case. One may remain in an ague district during the day without becoming infected, but sleeping in it is nearly certain to impart the disease. This is, doubtless, partly owing to the increased malarial emanations during the night, but, to a less extent, to the increased susceptibility while sleeping.

Practical Rules Concerning Sleep.—1. *Amount of sleep required.* It is impossible to lay down any fixed rule applicable to all persons and circumstances. The amount of sleep required, like the amount of food, varies greatly.

Habitual deficiency of sleep produces a condition of wretchedness and prostration, with great restlessness. Prolonged watching inevitably breaks down the constitution. Not the least evil consequence of irregular and deficient sleep is, that sleep, when desired, is often courted in vain.

Habitual excess of sleep produces a condition of brain less active than usual, and less favourable for thought and action. Impressions are received less readily, and the power of will is correspondingly diminished.

The amount of sleep required varies with—

(1) *Age.*—The infant, if healthy, spends the larger part of his existence in sleep; gradually the amount required diminishes until, for the adult, seven or eight hours suffice. Children over two or three years old require sleep only during the night; and this is to be encouraged, as sleep during the day prevents fresh air and exercise. In advanced life there is a tendency to revert to infantile habits, sleep occurring in frequent short snatches.

(2) *Sex.*—Women seem to require rather more sleep than men, probably owing to the greater impressibility of their nervous systems. The hours of sleep required have in accordance with this view been stated to be, "Six for a man, seven for a woman, and eight for a fool."

(3) *Temperament.*—Those of a cold lymphatic temperament require more sleep than sanguine or nervous people, though the latter sleep more deeply. Frederick the Great, John Hunter, and Napoleon I. are said to have required only five hours' sleep per day; but the last of these had the faculty of taking short naps at a few moments' notice.

(4) *The sick and convalescent* require much more sleep than those who are healthy.

(5) *Habit* has a very important influence. There can be little doubt that many people sleep too much, and thus dull to some extent their mental faculties; but on the other hand, modern life, with its nervous strain, keen competition, and constant hurry and worry, makes it necessary to have a larger amount of sleep than our forefathers required.

(6) *Occupation.*—Mental work requires more repose than physical.

2. *Relation of sleep to food.*—The molecular life of the tissues—that is, the processes of nutrition—ought to be undisturbed. These go on most perfectly when no active function, such as that of digestion, is being performed. In fact, it is as difficult for them to build up their tissues during the performance of an active function.

as it is for us to sleep while driving over a rough road. But while the stomach carries on the digestive functions to only a small extent during sleep, the intestines continue still to digest and absorb food. In accordance with these facts, it is advisable to allow at least two hours between the last meal of the day and sleep, especially if animal food has been taken.

3. Remembering the facts that absorption is increased and the temperature is lowered during sleep, it is important to *sleep in pure air*, and to have *warm coverings*, especially about the shoulders and arms. There is a common tendency, especially with children, to throw all coverings off the arms and shoulders; and many an obstinate cough might be cured by the simple expedient of wearing a flannel jacket at night.

4. *Sleep during the night and not during the day.* It would hardly be necessary to say this, as the universal instinct of animals shows its advisability; but, unfortunately, the habits of mankind have commonly led to a partial reversal of the natural arrangement.

Watchmen and night policemen not uncommonly suffer from their forced night occupations. They miss the sunlight, and have to endure a lower temperature, and the depressing influences of a more solitary life.

An after-dinner nap is an enervating luxury, except in hot climates, and under special circumstances.

5. The room should be dark; light, like sound, is inimical to sleep. The head should be moderately raised. The temperature of the room for robust persons need not be artificially raised.

Sleeplessness, as a rule, occurs only when some physiological law has been broken. To relieve it, it is essential to equilibrate muscular and mental functions. Increase of muscular exercise is an important element in its treatment. In addition it is advisable not to have any severe mental work during the evening, nor to indulge in late suppers. Sleeplessness is the bane of many men of a nervous temperament, and chiefly attacks those of sedentary habits. It is apt to recur, and for this reason, if for no other, narcotics

ought to be scrupulously avoided. The habit of taking such soporifics is unfortunately becoming much more common, and is productive of many evils. Death from accidental overdose is a frequent calamity, and the dose in all cases requires to be gradually increased, until most injurious quantities are necessary to induce sleep. The consequence is that the poor invalid's nervous system is completely ruined, his power of will is annihilated, and he becomes the miserable slave of an evil habit, whose end is death.

CHAPTER XXXV.

PERSONAL HYGIENE *(continued)*—CLEANLINESS.

The Structure of the Skin.—Effects of Uncleanliness.—The Uses of Soap.—The Uses of Baths.—Varieties of Baths.—Swimming.—Cleanliness of the Person, Apparel, House, and Street.

Physiological Considerations.—The skin consists of a superficial part or epidermis, and a deeper part called the dermis or cutis. The epidermis is composed of a number of layers of minute cells, which when they reach the surface become dry, and are cast off as flakes or scales, commonly known as "scurf." Nails and hairs are composed of modified and hardened epidermal cells. Singeing the ends of hairs is now commonly recommended, with some idea that the nourishment is thus retained, but this is altogether fallacious, as there is no central cavity in the shaft of hairs, and no fluid in the hair which could escape.

Certain tubes open on the surface of the skin, penetrating at their deeper ends into the cutis. These are of two kinds, sweat or *sudoriparous glands*, and *sebaceous glands*. The sudoriparous glands are simple tubes, the lower ends of which lie coiled up in the dermis.

Each tube when straightened out is about a quarter of an inch long; it contains a central canal, into which the perspiration is poured. It has been estimated by Sir Erasmus Wilson that in the

palm of the hand there are 3,528 orifices of sudoriparous and sebaceous glands on a square inch of surface; reckoning each gland as $\frac{1}{4}$ inch long, this means $73\frac{1}{2}$ feet of tubes in this small space. Assuming that there are 2,800 tubes to every square inch, and that the amount of surface in a man of ordinary height and bulk is 2,500 square inches, it follows that there are seven million pores in a man—that is, 1,750,000 inches, or nearly twenty-eight miles.

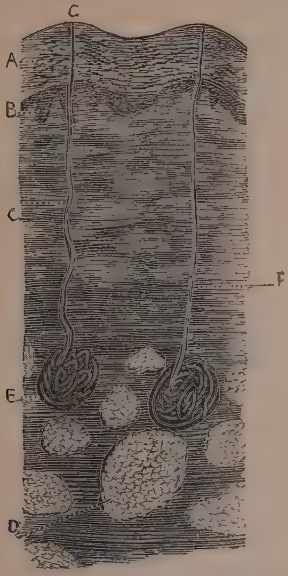


FIG. 34.—VERTICAL SECTION OF THE SKIN. Highly magnified.

A—Cuticle or Epidermis.

B—Rete Mucosum.

C—True Skin or Dermis.

D—Fat Cells.

E—Coiled extremity of Sudoriparous gland.

F—Sudoriparous gland running spirally to

G—Its Orifice on the Surface of Epithelium.

The sudoriparous glands secrete the perspiration. This is constantly evaporating from the surface of the body, though to a much greater extent in hot weather and during severe exertion. It is very important that the orifices of these glands should be kept open in order that the secretion may not be interfered with. Animals have been speedily killed by covering their skin with gelatine, and so preventing the escape of perspiration. Some idea of the amount of perspiration may be gained from a remark of Boërhave, that if the piercing chill of winter could be introduced into a summer assembly, the insensible perspiration (that is, the perspiration

slowly evaporating, and never appearing on the skin as beads of sweat) being suddenly condensed, would give to each person in the assembly the appearance of a heathen deity wrapt in his separate cloud.

The sebaceous glands are shorter than the sudoriparous, and commonly end alongside the hairs before the latter issue from the skin. They secrete an oily material which serves the purpose of a natural pomade, and renders any artificial hair-oil in most cases unnecessary. The sebaceous secretion also keeps the general surface of the skin unctuous and supple, and prevents dryness and harshness, if perspiration is deficient; or if the latter is great, prevents the macerated condition—somewhat like the hands of a washerwoman—which would otherwise be produced. The smell of the sebaceous secretion is not pleasant, especially in the arm-pits and some other parts. It is important for this reason that it should not be allowed to accumulate.

The **Conditions Due to Uncleanliness** may be classed under two heads; those due to obstruction of the excretory ducts, sebaceous and sudoriparous; and those due to accumulation of *débris* on the general surface of the skin.

1. The *obstruction* of the sudoriparous pores of the skin interferes with the elimination of waste products by the perspiration; these are re-absorbed or retained in the system, the consequence of which is that more work is thrown on the lungs and kidneys, and the equilibrium of health is destroyed.

The sebaceous obstruction causes an accumulation of oily secretion in the ducts. The black spots so commonly seen about the nose, are the blocked up orifices of sebaceous glands, and by squeezing the nose tiny threads of fatty matter are forced out from the interior of these glands. Pimples on the face are usually due to obstruction of the sebaceous glands; sometimes the obstruction leads to inflammation around the sebaceous gland, a condition known as Acne, which often permanently injures the skin.

2. *Accumulation* of effete matter on the skin occurs, unless frequent ablutions are performed. The epidermis is constantly shedding its older and more superficial parts, in the form of minute scales or "scurf." In the absence of frequent washing, the scales of epithelium tend to accumulate unduly, owing partly to the clothing preventing free exposure to air and escape of the scales; and partly to the sebaceous secretion matting the scales together, and rendering them more adhesive. The saline matters of the perspiration also accumulate along with the scales and sebaceous secretion, and in virtue of their hygroscopic properties tend to keep the skin clammy and cold.

The obstruction of excretions and the accumulation of *débris* lead to other consequences. Thus :—3. The *sensibility of the skin* is dulled when the sensory papillæ are covered with dirt. The sensations received by the skin are important in regulating the temperature of the body. A cold external temperature should cause a reflex contraction of the small arteries bringing blood to the skin, thus diminishing the flow of blood and preventing undue loss of heat. Similarly, if the external temperature is high, or the internal development of heat is too great, these arteries dilate, and sending more blood to the skin, cause a greater loss of heat by radiation and conduction. Impaired sensibility of the skin leads to a deficient reaction of the reflex nervous mechanism to which the above effects are due, and consequently the dangers resulting from sudden alterations of temperature are greatly increased.

4. The *tendency to chills* is increased, not only by deficiency of the nervous tone of the skin, but also by obstruction of the pores of the skin, and by the hygrometric action of the saline matter collected on it.

5. *Cutaneous diseases* are due to, or favoured by, uncleanliness. These are of two kinds—*parasitic* and *non-parasitic*. Acne, which is the chief non-parasitic disease favoured by uncleanliness, has been already mentioned.

Parasitic skin diseases are greatly favoured by the presence of

a dirty skin, which affords a suitable soil for the development of the parasites. *(See also Chapter XXXVI.)*

Uses of Soap.—Soap is produced by the action of an alkali on an oil. The alkali displaces glycerine from the oil, and forms an alkaline stearate, which is soap. Soft soap is stearate of potassium; hard soap is stearate of sodium. The former is not used for washing the skin, as it is too irritating. The differences between the various kinds of hard soap are insignificant. All contain a slight excess of soda; the greater this excess, the more irritating is the soap to delicate skins. If any irritation is produced by the use of soap for washing the face, a solution of a teaspoonful of sal-volatile in a quart or more of water may be used instead, or the unpleasant effects may be subsequently removed by rinsing the surface with water slightly acidulated with lemon juice. Hard soaps may be also made with potash, if the fat employed be a solid one; but such soaps are rather softer than ordinary hard soaps, and more caustic. Cocoa-nut oil is used in making marine soaps, because, unlike all other kinds, it is not rendered insoluble by brine, and so will form a lather with sea-water.

In washing the skin, the water washes away a considerable amount of epidermis, and the saline matters which have collected. But between water and the sebaceous oily secretion there is a natural antipathy; and as this is the most ill-smelling part about the skin, something more than water is required for cleanliness. This is provided by soap. The alkali in soap combines with the oily matter, forming an emulsion which carries away with it a quantity of the dirt, which usually blocks up the orifices of the sebaceous ducts. At the same time the orifices of the sweat glands are cleared out, and any remaining dead epithelium is carried away in the alkaline lather. When the skin is rubbed by the towel after washing, the softened epithelium, and with it any remaining dirt, is rubbed off, leaving the skin clean, and much more capable of performing its normal functions.

Substitutes for soap, such as the various "wash-powders" for the

toilet, are of little use. They only half do their work, as they do not enter the crevices of the skin, nor remove the obstructions in the glandular orifices. The common excuse for their use is that soap produces irritation of the skin; but good soap never irritates the delicate skin of infants. Irritation denotes neglect of soap, or a condition of the skin approaching disease.

The Use of Baths.—The primary object of bathing is cleanliness; inasmuch as cleanliness is necessary for health, the maintenance of health is involved in the use of baths. A secondary consideration is the pleasure derived from bathing. Baths are especially necessary for those persons who lead sedentary lives. When the skin is kept in an active condition by exercise, it to some extent cleanses itself. Thus, a farm labourer who has a weekly bath, may be really cleaner than a person of sedentary habits, who has two baths per week.

Baths are classified according to temperature as follows:—Below 85° Fahrenheit they are described as *cold*, though it is obvious that there are many gradations of temperature between 32° and 85° F.; between 85° and 95° they are called *tepid; warm* between 95° and 98°; and *hot* between 98° and 105°. It is very important in deciding the temperature of a bath not to trust to one's sensations; the only accurate measure is by the thermometer. A cold morning tub in the summer will commonly contain water at 55° to 60°; while the same in winter will be down to 40°, or occasionally to 32°. It may be desirable for weakly persons, in winter, to bring the temperature of the morning bath up to 50°.

For purposes of cleanliness the *warm bath* is the most efficient, combined with the free use of soap. It is most effective in thoroughly cleansing the skin, and increasing the rapidity of its functions. The chief objection to it is that it produces an increased flow of blood to the skin, by relaxing the cutaneous blood-vessels; in consequence of this the danger of chills is greatly increased. A severe catarrh or a quinsy is no uncommon result of warm baths taken at public bath-houses. Warm baths ought not to be taken

by healthy individuals oftener then once a week, and then at night, so that any exposure to subsequent cold is unnecessary. The increased sensibility to cold resulting from a warm bath may at any time be obviated by afterwards rapidly sponging the body all over with cold water, and then drying the body quickly, and using the friction of a moderately rough towel. It is desirable for both cold and warm baths to have a "bath-sheet," in which the person may be completely enclosed on coming out of the bath. Drying is thus much more quickly accomplished, and the danger of chill is minimised.

A daily morning *cold bath* is a most important agent in the maintenance of robust health. The first sensation on entering a cold bath is of shock, due to the cooling of the surface of the body. This is followed in a few seconds by a glow, due to the blood returning with considerable force to the skin. A cold bath ought not to be slowly taken, but as rapidly as possible. If soaping the body is desired, it should be done before entering the bath, and the stay in the latter should be little more than momentary. In this way the best reaction, or in other words, the best glow is obtained.

If a feeling of cold and chilliness remains after a cold bath, it has done more harm than good. This condition may often be avoided by drying quickly and brisk friction; if after this a good reaction is not obtained, the temperature of the water should be increased. For those who are not very robust, the "cold tub" in winter is to be deprecated. Water at 45° F., or even lower, produces chilling without any reaction; whereas, if the water be raised to 60° by the addition of warm water, or in some cases even to 70°, a good reaction will be obtained. In other cases, in which a reaction is not experienced even after a bath of the latter temperature, a tepid bath may be taken, and then the body rapidly sponged with colder water.

It is important, in relation to cold baths, to gradually accustom oneself to them, preferably beginning them in summer, and, unless

robust, to avoid very cold water. If a chill follows a bath, a cup of hot drink, such as tea, will obviate its effects.

Cold baths increase the tone of the skin, rendering it less susceptible to changes of temperature. The tendency to "catch cold" is greatly diminished, the blood-vessels and nerves of the skin both responding more readily to any stimuli. The cutaneous nerves become "hardened" by the sudden shock of cold water, and so morbid reflex actions, resulting in catarrhs, are much less prone to occur.

Swimming is a very valuable combination of bathing and exercise. A sudden plunge into cold water for swimming purposes is dangerous to those who are not hardened to it, and especially so in the case of running water, as in rivers, or the sea. Here the water around the swimmer is constantly being changed, and each layer of water coming in contact with him abstracts a considerable amount of heat. Many of the cases of so-called death from "cramp" are really due to the benumbing and depressing influence of continued cold on the vital organs.

Swimming, under proper superintendence, ought to be universally enforced. The exercise accompanying it serves in most cases to counteract the depressing action of the cold water; but it is important in all cases to attend to certain rules. The immersion should not be prolonged; the body should be warm at the time of entering the water; and the bath should not be taken until about two hours after a meal; nor after prolonged fasting, as before breakfast.

Personal Cleanliness.—Personal cleanliness involves not only attention to the skin, which we have already considered, but to the hair, nails, mouth, and other parts of the body.

The *hair* ought to be carefully brushed and combed, but it is not desirable to use soap to it as often as to the skin. Soap takes away the sebaceous secretion from the hairs, and renders them dry and brittle. Artificial pomades are, as a rule, undesirable and unnecessary, the sebaceous secretion furnishing the necessary oily

material. Where this is deficient, it is preferable to cut the hair short, thus diminishing the length of hair requiring lubrication; if this fails, then the aid of pomades may be invoked.

The *nails* should be cut square, and not down at the sides. It is hardly necessary to say that they should be kept clean: the finger-nails of medical men have been known to carry about infection of a serious character.

The *mouth* and all mucous orifices should be kept scrupulously clean. A fœtid breath is not uncommonly due to the discharges from carious teeth, or to the decomposition of food which has been allowed to accumulate in the cavities of teeth. Such decomposing matters when swallowed, are apt to lead to indigestion; and this also occurs from imperfect mastication of food by the bad teeth. It is important that the *teeth* should be frequently cleansed, and that all carious teeth should be "stopped" at an early period, and tartar and other accumulations removed. Whether bad teeth, which are so extremely common, are due to the drinking of very hot liquids, or to deficient calcareous matter in the food, or (which is more probable) to hereditary weakening, owing to more perfect cooking of food rendering mastication less necessary, there can be no doubt that by keeping the mouth thoroughly sweet and clean, and by stopping carious teeth as soon as discovered, their vitality may be greatly prolonged.

General Cleanliness.—Next to cleanliness of the skin, that of the *apparel* is most important. It is rather absurd to think that, as a matter of fact, the only covering a man is born with is commonly less clean than the apparel he clothes himself with; and that if any article of clothing is less clean than another, it is the one he wears next his skin. He has a clean vest less often than a clean shirt, and a clean skin less often than either.

The same tendency to disregard cleanliness is shown by the general preference for colours "that do not show the dirt;" the fact that it is still there, though not seen, being ignored. It would be much better for the health of the community if every one were

obliged to dress in white or light-coloured clothes; there would then be some hope of cleanliness being maintained. Changing of apparel is commonly confined to underclothing. It is forgotten that vests, trousers, dresses, etc., acquire a large amount of dirt and organic matter, and ought to be changed and well aired at frequent intervals. It is well to spread out one's clothes in a dressing-room at night, in order to have them well ventilated and purified by the oxygen of the air.

Cleanliness in respect to *bed-clothes* is very important. Organic matters evolved from the skin, lungs, etc., hang about the bed-linen, and give the bed-room the "close smell" which can nearly always be appreciated on entering it in the morning straight from the fresh air. The beds should not be made directly after being evacuated, but the clothes should be thrown over the bottom of the bed, the bolsters and mattress well shaken, and every part exposed to a free current of air during the greater part of the morning, before re-arranging the clothes. Restless nights are not uncommonly due, in part, to impure bed-linen poisoning the skin. Eider-down quilts, unless frequently ventilated by exposure to outside air, act as receptacles of dirt and organic effluvia. Superfluous bed-room furniture should be avoided, as it all takes away from the breathing-space. Bed-hangings should be reduced to a minimum, and all excretory matters covered up during their stay in the room, and removed as early as possible.

Cleanliness of *the house* is also very important as a means of health. Dust, in however obscure a corner it rests, attracts to itself organic matters, and forms a soil in which disease germs are propagated. Besides this, it devitalises the air, that is, deprives it of its active oxygen.

Dust in *the streets* serves to carry about various diseases. There can be little doubt that infection is sometimes spread in this way. In addition to this, dust mechanically irritates any part it comes in contact with, producing bronchitis, etc.

CHAPTER XXXVI.

PARASITES.

Vegetable Parasites.—Schizomycetes.—Saccharomycetes.—Thrush.—Ring-Worm.—Favus.—Tinea Versicolor.—Scabies.—Fleas, &c.—Trematodes.—Nematodes.—Filariæ.—Tape-Worms.—Preventive Measures.

Parasites (Greek, *para*, upon, and *siteo*, I feed), in the broadest sense of the word, are living organisms, which derive their nourishment from other living organisms. They may belong to the vegetable or animal kingdoms, and may live on the skin, in the alimentary canal, or in some one of the internal organs. In some instances, as in ringworm, the organism feeds on the living tissues of the animal infested; in others on the partly digested food, as in the case of tape-worms; while other parasites only pay temporary visits to the surface of the body, for the purpose of obtaining food, as in the case of fleas and gnats.

The importance of the different parasites varies greatly; some being the cause of active disease, while others are comparatively harmless. Only the commoner and more hurtful varieties will be here described, the rarer ones being simply named.

Vegetable Parasites.—Vegetable parasites all belong to the class of fungi, and more accurately to the two lowest divisions of this class which have been provisionally formed, viz.—Schizophyta, and Zygophyta. The Schizophyta include two orders, Schizomycetes and Saccharomycetes.

The *Schizomycetes* are minute cellular growths; the cells of which may be isolated, in which cases they are spherical (Micrococcus), or rod like (Bacterium); or united into filaments which are straight (Bacillus), or spirally wound (Spirillum). None of these contain chlorophyl; they multiply by fission, occasionally by the development of spores, and occurring in swarms, they may in a certain stage be imbedded in a gelatinous matrix (the zooglœa stage). They are all extremely minute, the Bacterium being about $\frac{1}{10000}$ of an inch in length, and the Micrococcus rarely more than $\frac{1}{25000}$ of an

inch in diameter. Certain organisms belonging to these divisions have lately assumed much greater importance, owing to their intimate relation to the causation of disease. Micrococci have been found in the blood in various septic (blood-poisoning) diseases, such as pyæmia, septicæmia, and puerperal fever, and they must be regarded as the active cause of these diseases. They have also been found in the system in various specific contagious diseases, such as diphtheria and vaccinia (vaccination), but their exact relation to these diseases is still not certainly determined.

Bacteria of various forms are found everywhere. The *Bacterium termo* is apparently the cause of putrefaction, as, in its absence, freedom from decomposition can be ensured.

Another form of Bacterium seems to be the cause of pèbrine—a disease of silk-worms—which has caused great loss in France, and has recently been thoroughly investigated by Pasteur.

To avoid confusion, it may be stated that the term Bacterium has been applied to all the organisms belonging to the Schizomycetes, though strictly it applies only to the rod-shaped isolated organisms.

A form of Bacillus, called the *Bacillus Anthracis*, has been proved to be the cause of malignant pustule of man, the splenic fever of animals. The close association of the *Bacillus tuberculosis* (Koch) with the origin of tubercular consumption, is discussed in Chapter XXXVII.

A form of Spirillum has been found in relapsing fever, which appears with each paroxysm of the fever, and disappears in the intervals. It is called *Spirochæte Obermeieri*, from Obermeier, who first described it.

Saccharomycetes occur in fermenting substances, as in the fermentation of saccharine solutions. The only organism belonging to this order, which is associated with diseased conditions, as the *Sarcina Ventriculi*. This is found occasionally in the vomit or even in the urine of some persons.

The *Zygophyta* occur as thread-like growths, forming a mycelium,

This is composed of jointed branching tubular cells, in which minute spores are produced. Each spore, when liberated from its tube, is capable of producing another mycelium, and thus the growth spreads. The spores may be carried through the atmosphere, thus producing infection at a distance. They are extremely minute, having an average diameter of ·006 m. m. (about $\frac{1}{4000}$ of an inch.)

The following are the chief Zygophytous parasitic diseases:—*Thrush* is associated with the growth of a minute filamentous fungus, the *oidium albicans.* It is common in babies, who are improperly fed, and in old people, or in persons exhausted by any chronic disease. Small white patches collect on the tongue and neighbouring parts, and these are often followed by the formation of minute ulcers. When it occurs in children, the food must be carefully attended to, and feeding bottles frequently scalded, etc. Glycerine of borax is generally applied to the interior of the mouth, but sometimes a weak solution of sulphurous acid is more efficacious. In all cases, it is important to treat the general health as well as the local condition, as thrush only comes on in weakly states of health.

Ringworm is due to the growth of a fungus, the *tricophyton tonsurans*, which may attack the skin of the body, or the scalp, or the beard. It is much more difficult to eradicate when it occurs in hairy parts, as the fungus growth penetrates to the roots of the hairs, and continues to live here long after it has been destroyed on the general surface of the skin; it is also very difficult to cure in the rare cases in which the nails are attacked. The fungus spreads on the skin in gradually enlarging circles. When seen on non-hairy parts, it forms patches of varying size, having a slightly raised and inflamed margin. In all its stages, and wherever found, it is extremely contagious, being especially apt to spread in schools. The spores may be carried about by means of hats or bonnets, by gloves, towels, razors, and other means. Children not uncommonly get ringworm by playing with kittens or pups suffering from it. The disease often remains undetected for some time; and many

cases, after they have been apparently cured, remain contagious, and thus the disease is spread, while its presence is unrecognized.

The removal of ringworm, as of all other skin parasites, is effected by some local parasiticide. Iodine, sulphurous acid, carbolic acid, are usually effectual when the parasite attacks non-hairy parts: for the scalp and beard more penetrating remedies are required, and a longer perseverance in treatment. In addition to these remedies extreme cleanliness is essential in the treatment.

Favus is due to the growth in the skin of a minute fungus called the *Achorion Schönleinii*, which invades the same parts as those affected by ringworm, but differs remarkably in its mode of formation of spores; yellow cupped discs from $\frac{1}{4}$ to $\frac{1}{3}$ inch in diameter being produced. It is very rare in England, and almost confined to persons (especially children) who are kept in a filthy condition. It is a common and fatal disease in mice. The treatment is similar to that of ringworm.

Tinea versicolor is caused by the growth in the epithelial cells of the skin, of a fungus called the *microsporon furfur*, which unlike the two last, does not invade the hair or nails. It forms light brown patches covered with a horny scurf, which gradually spread, until nearly the whole trunk may be covered. It does not attack children, and never affects uncovered parts of the body. It chiefly occurs in those who do not take frequent baths, and who perspire freely. It can be removed by daily washing with soap and water and rubbing with a rough towel, followed by the application of a weak carbolic lotion.

Animal Parasites.—Animal parasites are found on the skin or in internal organs. In the latter case, they may have gained access through food or drink taken, or by penetrating the skin. All the animal parasites belong to the Invertebrate class. The following is a fairly complete list:—

The *Acarus Scabiei* is a minute animal not unlike a cheese mite, which causes the disease known as *scabies* or the itch. It is probably never more than $\frac{1}{77}$ of an inch in length. The female has

eight legs, with terminal suckers on the four front legs and hairs on the hind legs. The male is smaller than the female, and in the adult condition the two hindmost legs have suckers, as well as the four anterior. It remains on the surface of the skin, while the female burrows deeply in the substance of the epidermis. At the bottom of the oblique burrow it deposits ten to fifteen or more eggs, which hatch in a fortnight and then commence similar operations on their own account. Scabies generally starts between the fingers, whence it rapidly spreads. It is almost entirely confined to those whose skins are uncleanly, and whose linen is seldom changed. Others, however, may catch the disease accidentally, and it may become very severe before its real nature is detected, the treatment being misdirected towards remedying some supposed disorder of general health, instead of towards killing the parasites. Occasionally whole families are infected by a nurse, or from some accidental source. Formerly it was called "the seven years' itch," from the great difficulty in curing it before its true cause was discovered.

The irritation caused by the insect produces various rashes which closely resemble the rashes due to constitutional causes, such as eczema. In some cases, the only certain means of diagnosis is by the microscope.

The removal of this parasite is effected by two measures. First the skin is softened, the superficial epidermis is removed, and the burrows are laid bare, by the daily use of hot baths with soft soap, and subsequent rubbing with flesh towels. Then some parasiticide, such as the well known sulphur ointment, is rubbed into all the affected parts of the skin. A few days' perseverance in this treatment usually suffices for a cure. The patient's clothes and bed clothes ought also to be thoroughly purified by boiling or dry heat; otherwise he may become re-infected.

The *Acarus folliculorum* is a minute insect, which is commonly found in the sebaceous follicles of apparently healthy people. It does not give rise to any disorder.

The *Larvæ* of several insects have been found embedded in the skin. In the ox, the larva or bot of the gadfly produces a troublesome disease, a large boil being formed under the skin as the larva grows. This larva has, on rare occasions, attacked human beings. Rare cases are recorded where other larvæ have become developed in men, in all upwards of twenty separate genera of insects having been recognised. The treatment consists in removing the parasite where possible, and where not possible killing it *in situ.*

The *Chigoe*, commonly known as the jigger or sand-flea, is a minute parasitic insect, found in the West Indies and northern parts of South America. It was formerly regarded as an acarus or mite, but is really a flea (*Pulex penetrans*). It is so small as to be scarcely visible; but the impregnated female possesses a proboscis, by which it penetrates the skin—generally near the nails—and there develops a bladder the size of a pea, which sets up severe inflammation.

To get rid of the intruder, the orifice by which it entered must be dilated with a needle, until large enough to admit of its extraction, without rupturing the cyst.

The *Leptus Autumnalis* or harvest bug, is apt to imbed itself in the skin, and cause great irritation.

Several species of *Fleas* infest the human frame. They are propagated by means of eggs, the worms from which enclose themselves in a tiny cocoon before assuming the adult form.

Three varieties of *Lice* occur on the human skin. The first (*pediculus capitis*) infests the head, especially of children, and multiplies with astonishing rapidity, the female laying altogether about fifty eggs. The other two varieties are the body louse (*pediculus corporis*) and the crab louse (*pediculus pubis*).

Strict attention to cleanliness is the best means of getting rid of fleas and bugs. A wash made of carbolic acid and vinegar painted over bed crevices is very efficient. Lice may be removed from the head by cutting the hair short, and rubbing into it a weak carbolic lotion, or white precipitate ointment.

The *Trematoda* or Flukes furnish two human parasites, viz. the liver-fluke *(Distoma hepatis)*, and the Bilharzia hœmatobia. The liver-fluke occasionally produces jaundice in man. In sheep it is the cause of the disease known as the "rot." The *Bilharzia hœmatobia* is chiefly found in Egypt, and the Cape Colony. It is about a quarter of an inch long, and infests the blood vessels, more particularly of the kidneys; setting up severe irritation and the discharge of blood. It is probable that the eggs of this parasite are received in drinking water or on salads, though occasionally inoculation may occur through the skin when bathing.

The family of *Nematoda* possesses numerous parasitic members. The common thread worm *(Oxyuris Vermicularis)* is one of the most common of these. The female is $\frac{1}{3}$ to $\frac{1}{2}$ inch in length, and inhabits chiefly the lower bowel. The ova, which are from $\frac{1}{490}$ to $\frac{1}{1100}$ inch in diameter, often gain access to drinking water, or are carried by flies, or received on salads, etc. The injection of salt and water into the bowel, and remedies tending to improve the general health, are the proper remedies.

The round worm *(Ascaris Lumbricoides)* inhabits chiefly the small intestine; hence medicines for its removal require to be given by the mouth. The female is from 10 to 14 inches long; the ova, of which each female discharges on an average 160,000 daily, from $\frac{1}{340}$ to $\frac{1}{440}$ inch in diameter.

The whip-worm *(Tricocephalus Dispar)* is a smaller trematode, which is rarely met with in this country. The *Dochmius Duodenalis* is met with chiefly in Italy and Egypt. It sucks the blood in the intestine, causing dangerous hæmorrhage. The *Strongylus Gigas* is chiefly found in the kidneys of the ox, dog, etc., and is very rare in man. It resembles a very large round worm. In the kidney it produces severe disorders, but how it gets there is not known.

The *Trichina Spiralis* has been already described (*page 35*).

The *Filaria Dracunculus* (Guinea Worm) seems to gain access into the stomach along with water, or possibly in some cases, by

perforating the skin. It burrows among the tissues, especially of the legs, and attains a length of several feet.

The *Filaria Sanguinis Hominis* is a minute worm, about $\frac{1}{75}$ inch long, which infests the blood of man, chiefly in the tropics. Its mode of entry into the system is doubtful, but it is probable that the ova of this worm may be introduced by mosquito bites, as well as by the drinking-water. Vast colonies of these worms circulate in the blood, and may produce various diseases. Commonly, if a drop of blood is examined during the day, no filariæ are detected, while at night they are present in abundance. It seems that they remain quiescent during the day, only migrating into the blood-vessels at night. The filariæ sometimes accumulate in the lymphatic vessels and glands, and produce obstruction of the flow of lymph or chyle. In some cases, as a result, *chyluria* (chyle in the urine) is produced; while in others *Elephantiasis*, characterised by enormous enlargement of the legs and other parts, ensues.

Tape-worms are found infesting the alimentary canal of man. Each has a double phase of existence. In the first, the characteristic head or *scolex*, along with a bladder-like body, lies imbedded in the solid tissues of an animal; in the second, the *strobilus* or tape worm, forming really a colony of animals, occupies the alimentary canal of another animal. The tape-worm consists of a number of flat segments, each of which is capable of producing eggs, from which a six-hooked embryo is developed. The segments escape from the alimentary canal, and their ova are discharged and scattered broadcast. These subsequently find their way into the alimentary canal of another animal, the hooked embryo escapes from its cell, migrates into the solid tissues, and there produces a scolex. The scolex remains *in situ* until its host perishes, or becomes the prey of another amimal. When the latter happens, the scolex enters the alimentary canal, loses its bladder-like body, and develops a chain of segments. It follows from the above that two distinct hosts are usually necessary to complete the cycle of

existence of these creatures, one being commonly a herbivoious, and the other a carnivorous animal. Thus:—

Cystic Form.		Tape-worm Form.
Cysticercus Cellulosæ in the muscles of the Pig ...	*becomes*	*Tænia Solium in the alimentary canal of Man.*
Cysticercus ———? in the muscles of the Ox ...	”	*Tænia Mediocanellata, in the alimentary canal of Man.*
Cysticercus Pisiformis in the muscles of the Rabbit ...	”	*Tænia Serrata in the alimentary canal of the Dog & Fox.*
Cysticercus Fasciolaris in the muscles of Rats and Mice	”	*Tænia Crassicollis, in the alimentary canal of the cat.*
Cœnurus Cerebralis of the Sheep's Brain	”	*Tænia Cœnurus, in the alimentary canal of the Dog.*
Echinococcus Veterinorum of the Liver of Man, etc....	”	*Tænia Echinococcus in the alimentary canal of the Dog.*

The *cysticercus cellulosæ* has been already described (*page 35*). The cystic form of the dog's tape-worm (*echinococcus veterinorum*) is one of the most dangerous parasites to life in man. It forms large cysts, chiefly in the liver, but occasionally in the lungs, brain, and other organs. For the removal of these, surgical interference is required. This form of cyst is commonly known as a *hydatid.* It is most frequently seen in Iceland and Australia, though not uncommon in this country. Its frequency depends largely on the number of dogs, and on the facility with which the ova of their tape-worms can gain access to water.

The adult *Tape-worms* are usually derived in man from eating meat containing the cystic form. The *cysticercus* of the pig produces *Tænia Solium;* that of the ox, the *Tænia Mediocanellata.*

Preventive Measures.—In avoiding the various Entozoa described, it is important (1) to *carefully avoid all underdone meat.* The eating of smoked sausages, or of meat which is not cooked throughout, is a common source of tape-worm and of trichinosis.

(2) *All vegetables should be thoroughly washed:* this is especially important in the case of water-cress, lettuce, etc., which are eaten raw.

(3) If the purity of the *water* is not ensured, it *should be boiled* before drinking, especially in tropical climates, and where many dogs are kept. Dogs should be kept out of the kitchen, lest ova accidentally gain access to articles of food.

(4) The possibility of *flies* and *mosquitoes* acting as carriers of parasitic disease must be remembered.

(5) Intestinal parasites, as a rule, occur in debilitated persons, and especially in those suffering from some abnormal condition of the mucous membrane. It is essential, therefore, that this should be treated, and that the general health should be improved by medicinal and other measures.

CHAPTER XXXVII.

THE PREVENTION OF ENDEMIC DISEASES.

Endemic and Epidemic Diseases. — Consumption. — Influence of Heredity, Sub-soil Drainage, Overcrowding, and Infection.—Scrofula.—Rheumatic Fever.—Marsh Diseases.—Rickets.

The prevention of disease depends largely on a knowledge of its causes. Disease may be due to a personal life not in accordance with physiological laws; or to some other cause acting *ab extra*, whether it be conditions of atmosphere or soil, or some contagion received into the system.

We have already discussed the influence of habits, of clothing, exercise, sleep, and food on health, and have shown how errors in these respects may lead to disease. It now remains to consider more particularly the prevention of diseases, which are to a large extent independent of personal habits of life. Many such diseases are unfortunately not preventible; but there can be no doubt that with increased attention to the condition of air and water, of drainage of the soil and allied matters, the number of inevitable diseases will be greatly diminished.

The chief preventible diseases come under one of two heads :—

those which are constantly present in a smaller or larger degree, and those which only appear periodically. The former are called *endemic diseases*, the latter *epidemic diseases.* It must be remembered, however, that many epidemic diseases, like typhoid fever, are prevalent in a less degree constantly, and are therefore endemic; while certain endemic diseases, like leprosy, plague, and yellow fever, become epidemic under certain ill-understood conditions. The chief endemic diseases we shall consider are—consumption, scrofula, rickets, rheumatic fever, and ague; the chief epidemic diseases—small-pox, scarlet fever, diphtheria, measles, whooping cough, typhus and typhoid fevers, cholera, and dysentery.

The Prevention of Consumption.—There can be no doubt that this is a disease which is entirely preventible. There are four main factors in its causation—1st, its marked hereditary character; 2nd, the influence of sub-soil drainage; 3rd, the influence of overcrowding: and 4th, its possible contagiousness. When we remember that phthisis (consumption) kills more than 80,000 persons per annum in the United Kingdom, or 11 out of every 100 persons, and that other phthisical and scrofulous diseases kill a large additional number, the importance of studying the conditions on which it depends is evident.

Its *hereditary character* is well known; too much stress must not however be laid on this point, as there are few families in which some relatives have not died of consumption. On the other hand, if several members of the same family have successively died of consumption, the project of an alliance by marriage with any remaining member of the family should on no account be entertained.

The influence of sub-soil drainage on the prevalence of phthisis has been clearly shewn by Dr. Buchanan (9th and 10th Reports of the Medical Officer to the Privy Council, 1866-7). He found that as the sub-soil water was diminished by means of drainage, the mortality from phthisis diminished. It was also found that the mortality from phthisis was reduced more in the early years after

drainage works were completed, than in later years, because the sewer-trunks tended to become consolidated and impervious. The obvious inference from this is that inasmuch as sewer-pipes carrying off excretal products are required to be impervious, a separate system of sub-soil drainage is desirable. *(See page 298.)*

Overcrowding has a very important influence in producing phthisis. Dogs in badly ventilated kennels, horses or monkeys under similar conditions, not uncommonly die with all the symptoms of galloping consumption.

Dr. Parkes gives statistics from a badly ventilated prison in Vienna (the Leopoldstadt) which illustrate the same point. In the years 1836-47 the deaths were 86 per 1,000, of which 51·4 per 1,000 were due to phthisis. At the same period in the well-ventilated House of Correction in Vienna, under similar diet and modes of life, the deaths were 14 per 1,000, of which 7·9 were due to phthisis. Apparently then 43·5 per 1,000 of the deaths from phthisis in the former case were attributable to foul air (and possibly infection from one patient to another).

Examination of army statistics gives similar results. The Sanitary Commissioners for the Army, in a now celebrated report, found that before the Crimean War at least two soldiers died for one policeman. They eliminated from their statistics all foreign regiments; and,—spite of the fact that unsatisfactory recruits are rejected, and that soldiers are not more heavily worked and are better clothed than policemen,—they found that while in the Foot-Guards the mortality was 20·4 per 1,000, and in the Infantry of Line 17·8 per 1,000, in the Metropolitan Police it was only 8·9 per 1,000; more than half the high mortality in the first two being due to lung diseases, and especially phthisis. It was found that the air of the barracks was disgustingly foul, and that the men were crowded together in a very insufficient space. The ventilation and drainage of the barracks were improved, and a speedy improvement resulted. While thirty years ago phthisis killed eight soldiers per 1,000 every year, now barely three per 1,000 die; while formerly two

soldiers died of phthisis for every civilian, now four civilians die for every three soldiers.

As still further confirming the view that vitiated air was the chief cause of the excessive prevalence of phthisis in the Army, before and about the time of the Crimean War, we may note that during the twenty-two weeks in which part of the British Army was before Sebastopol, the mortality from every cause, including violence and accident, was only 12½ per 1,000, or nearly ⅓ less than that of the Infantry of Line, and ⅔ less than that of the Foot-Guards in England.

The *possible contagiousness* of phthisis, under certain conditions, has been surmised in former times; but the facts bearing out this view have been so few, that it has not found general favour. But some recent researches go far towards disproving the ordinary views of the cause of phthisis. In starting, we must remember that consumption is a wide name, under which several different diseases have been included; the only true phthisis, however, being that characterised by the formation of small-celled growths, called *tubercles*. This is the form of consumption which is now asserted, under certain conditions, to be contagious. The facts on which this assertion is founded are two-fold.

1. It has been found that when tubercle is inoculated locally in any animal, it leads to the formation of a local tubercle, and after a variable time a large number of tubercles scattered throughout the body (general tuberculosis); and the virus increases in activity by inoculation in a series of animals. On the other hand it has been found that the tubercles produced by the injection of non-tubercular foreign matters never lead to general tuberculosis, and after several injections become quite inoffensive.

2. Koch has found in the true tubercular growths (and even in the expectoration of phthisical patients) microscopic organisms, which he calls *tubercle-bacilli;* these appear as delicate rods from a quarter to half the size of a blood-corpuscle in length, some of the rods possessing oval spores. These bacilli, which are really

minute vegetable growths, belonging to the class Schizomycetes, Koch was able to cultivate in a suitable medium outside the body; and after growing them for as long as fifty-four days, he inoculated various animals, producing tuberculosis in every case, while in similar check experiments in which all the conditions were the same, barring the absence of bacilli, no tuberculosis resulted.

That the tubercle-bacillus is the essential cause of tuberculosis seems fairly certain; and this fact does not in any measure contravene what has been said concerning the influence of a damp sub-soil or over-crowding in its causation. We may rather infer that the damp soil furnishes conditions favourable to the growth of the tubercle-bacilli; while over-crowding probably acts in the same way, and also by increasing the probability of dried sputa being inhaled. If it be true that phthisis may possibly be "caught" by breathing infected air, the importance of isolating consumptive patients and not allowing the healthy and diseased to sleep together becomes apparent. This has been already acted upon by the German Minister of the Interior as regards the state prisons. On the same principle the use of antiseptic inhalations has been found very valuable.

It was found by Koch that a minimum temperature of 84° Fahr. was required for the development and multiplication of the tubercle-bacillus. This may possibly account for the comparatively slight contagiousness of tubercle in this country, and also for the fact that in the south of Europe it is commonly regarded as a contagious disease. It will also explain the value of a dry and moderately cold climate in phthisis.

Prevention of Scrofula.—Scrofula is an affection of the lymphatic glands, most commonly of the neck, in which they become enlarged and inflamed, and commonly undergo chronic suppuration. The cheesy matter, which is usually found in the scrofulous glands, has been found to contain tubercle-bacilli, and we may regard scrofula therefore as a tuberculous disease, closely allied to phthisis.

But these bacilli do not appear to be always present, and it would seem that in many cases there is a preliminary condition before the formation of tubercle, in which cheesy matter may be present without tubercle. Similarly there may be a scrofulous condition of the lungs, having the symptoms of consumption, in the absence of bacilli.

Enlargement of glands is most commonly due to irritation of some neighbouring surface. Thus, the glands in the neck become enlarged in children from the irritation of sores or lice in the head, or in consequence of a discharge from the ears or a chronic sore-throat or the eruption of teeth. Usually these glandular enlargements subside when the irritation is removed, but in persons suffering from debilitated health or possessing an hereditary tendency to scrofula or consumption, the enlargement persists, and produces a cheesy degeneration of the glands.

The indications then in preventing scrofula are (1) to remove any skin or mucous irritation that may occur; and (2) to improve the general health by abundant fresh air, exercise, and food; thus removing the constitutional tendency. We may allude at this point to the fallacy of the popular notion that a discharge from the ear or a sore head must not be cured, lest a worse thing come to the child. Such a notion is productive of great evil, and many children's lives have been lost in consequence of it.

Prevention of Rheumatic Fever.—The occurrence of rheumatism is closely connected with a damp condition of the atmosphere and soil. In accordance with this, it has been found that the frequency of rheumatism (as of phthisis), diminishes when a good sub-soil drainage is established.

A serious chill, such as that from sitting in damp clothes, is the most common cause of rheumatic fever in predisposed persons.

The tendency to rheumatism shews a markedly hereditary character; in other words it "runs in families," the members of some families getting an attack on the slightest provocation, while others in the same circumstances escape. Not only is it hereditary,

but a previous attack renders one much more susceptible; as does likewise the occurrence of scarlet fever or child-birth.

The indications then in the prevention of rheumatism are to live in a dry place, to maintain the general health above par, and to avoid chills, particularly if one has had a previous attack of rheumatism or scarlet fever.

Gout is frequently mistaken for rheumatism, and the mistake is rendered greater by the frequent use of the hybrid term, rheumatic gout. Gout points as a rule to errors in diet, rheumatism to atmospheric conditions.

Prevention of Marsh Diseases.—Ague may be taken as the common name for the two chief varieties of marsh disease—intermittent and remittent fever. It occurs in low-lying marshy ground, which usually posseses a luxuriant vegetation, and a porous soil containing a large amount of decaying vegetable matter. In temperate climates it is most common in spring and autumn, and in the tropics occurs chiefly in the season of heat and drought following on the periodical rains. The upturning of soil which has been long untouched, has given rise to it in many cases. Damp, or a high temperature, or decomposing vegetation are not alone competent to produce it; but it is requisite that the soil should be porous and impregnated with water, and that the surface should then be quickly dried by a certain elevation of temperature (Bristowe). There can be no doubt that the malarious poison is exhaled from the soil along with the moisture, and more abundantly at night-time than in the day. In accordance with this, ground-floors of houses in ague districts are more dangerous to sleep in than are the higher storeys. In temperate climates the miasm is said not to mount above 500 feet, in tropical climates from 1,000 to 1,500 feet (Parkes). It is especially dangerous to sleep under trees in malarious places, as these form a kind of filter obstructing the poison. The water of malarious districts should carefully be avoided, or only drunk after boiling. The settled inhabitants of ague districts do not contract the disease so easily as persons newly arrived; negroes

for instance hardly suffering where Europeans rapidly die. It is important to remember also that when suffering from privation or fatigue, one is much more liable to an attack than when robust and well fed; and that one attack, unlike most fevers, renders the sufferer even more liable to subsequent attacks when fresh exposure occurs.

Ague districts may be rendered perfectly healthy by thorough drainage, as is shewn in the case of London, which was formerly marshy and aguish. The other points to be observed in the prevention of ague may be gathered from the above details.

Prevention of Rickets.—Rickets most commonly begins between the twelfth and eighteenth month of life. It is especially a disease of childhood, although occasionally developed as late as eighteen years of age; and is characterised by a softening and bending of the bones and an enlargement of them at their joint ends. There is a deficiency of lime salts in the bones, but it is not accurate to describe a similar deficiency in the food as the cause of rickets. The disease is rather due to a general lack of nutrition from improper feeding than to deficiency in any one constituent of food. This explains the fact that codliver oil is perhaps the most valuable remedy in rickets. It is not hereditary; but is most common in children who are badly fed and live in the midst of unhygienic surroundings. Thus it occurs chiefly in poorer children, and among richer children in those who have been artificially fed, and have had amylaceous food too soon, and a deficient amount of milk. The influence of premature weaning on its production has been already described (*page 39*).

For its prevention the child must have abundant fresh air and warm clothing, and his diet must be carefully regulated both as to quantity and quality. After its onset the same measures are required, together with others suitable for the prevention of deformities.

CHAPTER XXXVIII.

THE PREVENTION OF EPIDEMIC DISEASES.

Modes of Propagation of Epidemic Diseases.—Specificity of Contagia.—Germ Theory of Disease.—Modification of Bacteria by Alterations in Food, etc.—Two classes of Epidemic Diseases.—Small Pox.—History of Vaccination.—Theory of Vaccination.—Objections to Vaccination.—Scarlet Fever.—Measles.—Whooping Cough.—Diphtheria.—Typhus Fever.—Relapsing Fever.—Typhoid Fever.—Cholera.—Summer Diarrhœa.

Nature and Origin of Epidemic Diseases.—Epidemic diseases have also been called Specific Febrile Diseases, and Zymotic Diseases. The latter name has been given them on account of the resemblance to fermentation (zymosis) in their progress, but as this name involves a theory, the former name is preferable.

These diseases are characterised by certain definite characters.

1.—*They are usually infectious or contagious.* It is preferable to use these two terms as interchangeable, *contagium* signifying the specific poison (probably an organism) to which a specific fever is due. The modes in which infection is received vary greatly with the different fevers.

(1) Some can only be propagated by *inoculation*—the introduction through an abraded surface of a minute quantity of the poison; such are glanders and hydrophobia. Others, again, *may* be introduced in this way, which are usually acquired in another manner, as scarlet fever, small-pox.

(2) Some are carried through the *atmosphere.* The contagion of small-pox can be carried as far as any, while that of typhus fever only traverses a few feet. The state of ventilation will greatly influence the contagiousness of fevers, and in all cases a stagnant air containing the poison is much more infectious than one frequently changed. The atmosphere may be loaded with sewer gases, which contain products from previous cases of typhoid fever, cholera, etc. The long-lived character of the contagia of these diseases is very remarkable.

(3) *Clothes*, books, and furniture are not uncommonly carriers of infection. An old letter, or a lock of hair, has even after many years' concealment in an enclosed space produced infection on being brought to light. Woollen articles convey infection better than calico, and dark clothes better than light coloured. A fever nurse's clothes should never be woollen, but some other washing material.

(4) *Drinking water and food* are not uncommonly the source of epidemic diseases, usually from accidental poisoning of these by mixture with the contents of sewers or by the absorption of sewer-gas. Milk and water are the two usual sources of infection. Cholera, typhoid fever, dysentery, and summer diarrhœa are the chief diseases from this source; but scarlet fever, and probably diphtheria, occasionally have a similar origin. Milk absorbs morbid gases and vapours with considerable avidity (*page 37*).

2. *They retain their specific characters and origin.* Small-pox never produces scarlet fever, nor *vice versâ;* and it is found universally that all the specific fevers "breed true," each one retaining its identity. More than this, a previous case of the same fever can nearly always be detected on careful examination. Rarely do the infectious diseases appear to arise *de novo*, at the present time. It is true that unhygienic conditions, overcrowding, etc., increase the tendency to fevers, but these act chiefly by increasing the fertility of the special contagia. It has been asserted, however, that certain conditions may possibly determine the change of harmless bacteria into pathogenic (disease-producing) organisms; but the apparent transformation is probably the result of inaccurate observation.

3. *A minute amount of the contagium*, if received into the system, is as certain to produce the corresponding fever as a large dose, though judging by the varying severity of attacks of the same disease in different persons, the amount of poison received is of importance.

4. *The behaviour of contagia*, when received into the system, is characteristic of these diseases. There is first of all a period of

latency or *incubation*, during which no symptoms are manifested. This period varies for the different diseases, being two or three days in scarlet fever, ten days in small-pox and measles, ten to fourteen days in typhoid fever. In the case of hydrophobia, it may be several months; and in ague, several years. The incubation period is followed by the characteristic symptoms of the particular fever, which disappear in a variable period, leaving the patient, as a rule, *insusceptible to a second attack.* The contagium seems to exhaust the soil in which it grows.

Throughout the progress of the disease, except in the period of incubation, the patient is able to communicate his disease to persons about him who have not been rendered safe by a previous attack. The way in which he thus communicates his disease varies in different cases. In scarlet fever, the skin and throat are the chief sources of contagion; in influenza, whooping-cough, and measles, the breath and secretions from the respiratory passages; in hydrophobia, the saliva; in typhoid fever and cholera, the vomit and stools (and these especially if allowed to remain about; at first they are probably not infectious).

Character of Contagia.—(1) When we remember that the contagium of a particular fever produces that fever and nothing else; also (2) that the contagium, however minute in quantity, multiplies indefinitely in the system—and that one patient could, if brought in contact, furnish a supply of infection sufficient to convey his disease to thousands of persons—we are almost forced to conclude that these contagia must be living organisms.

This inference is borne out (3) by the analogy of the brewing of beer, the souring of wine, or of milk—all of which, as well as many other processes of a fermentative and putrefactive character, have been proved to be due to the growth and multiplication of microscopic fungi; and (4) by the knowledge that such microscopic *germs* are present in great numbers in the atmosphere.

There are special organisms (called *Bacteria*) for every specific fever (just as there are special seeds for every plant); and although

wonderfully minute, each of them (like the one mentioned as occurring in phthisis) has a special family history of its own. But, although this is true, it has been shown that the character and virulence of Bacteria can be modified by the *medium in which they are grown*; and it is quite within the range of possibility that the fever-producing Bacteria are modified forms from other Bacteria, which were formerly harmless,—virulence having been acquired, in consequence of the uncleanliness, overcrowding, and starvation which have been so common. Buchner thought he produced from a harmless Bacterium one which gives rise to a fatal disease (Bacillus anthracis), but his experiments have been more recently discredited. On the other hand, the Bacillus to which splenic fever (malignant postule, wool sorter's disease) is due, has been propagated outside the body, and so weakened as on inoculation in animals, to produce a modified and slight splenic fever, which, while it absolutely protects against a subsequent attack, does not produce any severe symptoms.

The importance of these researches cannot be exaggerated. They teach us two lessons, which may probably be applied to *all* specific fevers: (1) the specific germs of these diseases are capable of propagation outside the body; and (2) the virulence of their poison depends largely on the soil in which they grow; hence personal and general cleanliness and ventilation are of the highest importance.

Prevention of the spread of the Chief Epidemic Diseases.—We may divide the epidemic diseases into two classes. (1) Those which are infectious by contact with the patient or by the atmosphere around him. (2) Those in which the intestinal evacuations are alone contagious; as typhoid fever and cholera. It is evident that the former are by far the most dangerous as regards infection, and that for the latter the only requisite is to thoroughly disinfect the evacuations and secure that they do not obtain access to drinking water, milk, etc. The three chief measures available in any case are (1) Isolation, (2) Disinfection, (3) Vaccination of an attenuated virus. These will be discussed in detail afterwards.

Small-pox.—The contagium of this is very strong; and may be wafted from one side of a street to another. All parts of the body and all secretions and excretions contain the infectious material. Not only does it fix itself, as in typhus, to every article in the room, but is possessed of great vitality, and if not exposed to the air may be active after many years. To prevent the spread of the disease, the patient must be isolated; the attendants must have been re-vaccinated; the room must be well ventilated; all extraneous furniture, such as carpets and curtains, should be removed and disinfected; disinfectants should be constantly employed in the room; after convalescence the bedding and clothing should be stoved or burnt; and the room thoroughly disinfected. All persons over twelve or fourteen years of age, and all children whose vaccination marks are not large and distinct, should be at once re-vaccinated.

The chief measure in the prevention of small-pox is vaccination; and had this been universally adopted and efficiently performed, there can be no doubt that small-pox would be now extinct. The history of the origin of vaccination is highly interesting and instructive. Before its discovery, small-pox was an utterly loathsome disease; and, even if it did not kill its victim, involved serious consequences, such as blindness, deafness, deformity, and impaired health. In 1796, the year in which vaccination was introduced, more than 18 per cent. of the total deaths in Great Britain were due to small-pox; and in 1772 they were as many as 15 per cent. of the total mortality. Inoculation of small-pox, in order to produce a milder attack, was commonly practised; but inoculated small-pox was occasionally fatal, and it had this grave and insuperable drawback, that every case of inoculated small-pox became a fresh focus of infection, to which young children especially fell victims.

About the year 1795 Dr. Edward Jenner was informed by a milkmaid that she could not take small-pox, as she had already contracted the natural cow-pox during milking. Many had previously heard this same statement made; but Jenner was the first to put

the matter to the test. He took the lymph or virus from a woman who had accidentally acquired cow-pox (vaccinia) from a cow, and inoculated a boy with it. Some months later he inoculated the same boy with small-pox, and a second time five years afterwards, without producing small-pox on either occasion. Many other experiments were made, all confirming these results; and in 1798 Jenner published his results. Dr. Woodville, of London, confirmed these facts, vaccinating within two years as many as 7,500 persons, and subsequently inoculating about half these cases unsuccessfully with small-pox, and in other ways exposing them to the small-pox poison without any result.

The practice of vaccination gradually became more general, with the result of a progressive decrease in the mortality from small-pox. In the three years preceding 1840, the average yearly number of deaths from small-pox in England was nearly 12,000; during the years 1841 to 1853, in which vaccination was provided by the Government gratuitously, but was not compulsory, it was under 5,250; while, from 1854-63, after vaccination was made compulsory, the average annual deaths were only 3,350 (*see also page 9.*)

An analysis of 6,550 cases of all ages admitted into the Homerton Small-pox Hospital, from February, 1871, to December, 1878, shews that the mortality in the unvaccinated was 45¾ per cent., in those stated to have been vaccinated but without scars 27¼ per cent., in those vaccinated and presenting imperfect scars just over 11 per cent., while in those with good scars it was just under 3½ per cent. The exceptional occurrence of small-pox after good vaccination, is explained by the peculiar proclivity of some persons to catch infectious diseases: thus second and even third attacks of scarlet fever and measles are known to occur.

Cow-pox or vaccinia is probably small-pox modified and mitigated by its passage through the system of the cow, rather than a spontaneous disease of the cow, as is still maintained by the French school, in spite of evidence to the contrary. Vaccination, using the word to signify the inoculation of a mitigated virus, is at present only practised for small-pox; but what was discovered to all appearances accidentally in the case of small-pox, has lately in

the case of splenic fever been discovered by cultivation of the virus outside the body, and the production of an artificial mitigation. And in France this principle has been already applied for the prevention of splenic fever (charbon) in cattle, and thousands of lives and much money have thus been saved. Similarly in the case of hydrophobia, animals have been protected from subsequent inoculation of unmitigated virus, by the venous injection of a modified virus. It is quite possible that this principle of vaccination will become still further extended in the future, and that we may be able safely and certainly to prevent the onset of any fever. It is only fair to add that the matter is still *sub judice*, and that many other experimenters have failed to obtain Pasteur's results by cultivation.

Objection is taken to vaccination for small-pox on the ground that constitutional diseases may be inoculated at the same time. There can be little doubt, however, that with lymph obtained from healthy children and unmixed with blood this is impossible. Most of the cases of constitutional infection described have been in reality hereditary disease, the local irritation of vaccination serving to call into activity the morbid tendencies of the child. Even supposing it correct that some evil constitutional tendency or actual disease may be introduced by vaccination (which we deny except in very rare instances, where the vaccination has been carelessly performed), the cases in which this occurs are so very few that we are bound in our own interest to incur this remote risk, rather than the more certain risk of such a loathsome disease as is small-pox in its unmitigated form.

In answer to those who maintain that vaccination ought to be made optional, it is only necessary to say that the persons who would elect to remain unvaccinated, involve their children, who necessarily must abide by their parents' choice, in the same risk of deformity and death; and that all young children below the age when primary vaccination is considered advisable, are similarly involved in risk.

Scarlet Fever.—Scarlet fever is one of the most dangerous and contagious diseases known. It may attack persons at any age, but especially children under five years old. Its contagion

is very powerful, like that of small-pox, so that it is impossible to remain in the same room, or even in the same house, without great risk of infection to all susceptible persons, unless strict isolation is maintained. In many cases, second and even third attacks occur, but these are the exception; usually one attack confers immunity from the disease. It is well to get rid of the idea that *scarlatina* and *scarlet fever* are distinct diseases: they are one and the same disease, and, therefore, equally infectious—the name scarlatina (which would be better abolished entirely from our nomenclature) simply indicating a milder attack.

The disease is infectious during every part of its course, and *until after every scale has been completely peeled off the body.* Each scale is loaded with the specific poison of the disease, and ought to be prevented from floating about the room, or settling in various parts. This is done by keeping every part of the body oiled with olive oil, to which a little carbolic acid has been added.

The contagium retains its virulence for a long time, and persons sleeping in the room occupied by a scarlet fever patient months previously, have been known to contract the disease. The poison may likewise be sent from one country to another in an infected envelope or article of clothing; and where scarlet fever has occurred in a milkman's house, his customers have in several instances had the disease brought to them with their daily supply of milk.

In addition to keeping the body constantly oiled during the process of *peeling*, it is important that all cups and plates, and all soiled linen should be soaked in a weak carbolic solution or some other disinfecting liquid before leaving the room. The nurse ought not to enter the kitchen, nor be in direct communication with the rest of the house. No food should be allowed to leave the room and return to the kitchen. All the evacuations should be disinfected before removal.

After the patient has left the room, the bedding and mattresses should be removed and disinfected by great heat. The wall-paper

must be removed, and the room thoroughly fumigated with burning sulphur, and afterwards washed with disinfecting fluids, and allowed to lie fallow for some time before being re-occupied. All toys and books which have been in the room must be burnt.

Measles.—Here again the disease being extremely contagious, the same principles must guide one in preventing its spread as in scarlet fever. The patient should be carefully isolated, throughout the whole course of his disease, as infection is possible in the stage when there is simply a cold in the head without rash.

Inasmuch as measles is commonly not so dangerous as scarlet fever, the precautions for preventing its spread are, as a rule, neglected. It would be well if the common notion that measles, whooping cough, etc., must be had once in a life-time, could be eradicated. The idea seems to be prevalent that one must, so to speak, graduate in infectious diseases, and some even go so far as wilfully to expose their children to infection; or, if one has received an infectious disease, straightway put their other children in the same room, "to have it all over at one trouble!" Such an opinion concerning infectious disease is pregnant with evil results. (1st) Severe cases of these so-called inevitable diseases occur, in which a fatal result ensues; and even where death does not occur, the child may be left weakly and enfeebled in constitution. (2nd) Every additional case forms a new centre of infection. It is like the old practice of inoculation for small-pox: the individual is protected, but becomes a source of danger to all around him. If there is only one case of measles in a family the risk to neighbouring households is much smaller than where several children are infected. The wilful or careless multiplication of sources of infection prevents the desirable annihilation of measles and all other fevers, which is, with proper precautions, quite possible.

Whooping Cough.—Very few people have reached an adult age without having suffered from this disease, as well as measles. But the universal prevalence of these two diseases is chiefly due, as already stated, to the carelessness in mixing infected with healthy

children. One not uncommonly hears the peculiar and characteristic cough of a child with whooping cough, in public assemblies, in railway trains, or in the out-patient rooms of hospitals. The contagion of whooping cough, like that of measles, seems to be capable of travelling a considerable distance, so that isolation must be very complete in order to prevent infection. Clothing, again, conveys the infection easily; visiting of infected children should, therefore, be prohibited to all who have to mix with susceptible children.

The sick-room should be fumigated with carbolic spray, the bedding carefully disinfected, and preventive measures carried out almost as thoroughly as in the case of scarlet fever.

Diphtheria.—Diphtheria is closely associated in its origin with defective drainage. Unless there is a history of direct infection from another patient, we may assume that it is due to foul effluvia from cesspools or drains, or to milk specifically polluted by the poison of this disease. It is important, therefore, that the sanitary condition of the house should be at once investigated and all defects remedied. In the meantime, the drains should be flushed, and disinfectants freely employed.

The infection of diphtheria is not capable of being carried far in the atmosphere, being conveyed almost solely by the secretions from the throat, or by the excreta. It is important, therefore, that all the evacuations should be immediately disinfected, and that the breath of the patient should not be inhaled; kissing of the patient should not be allowed. The expectoration should be received into a vessel containing a disinfectant. It is advisable to use small pieces of calico to wipe the mouth and nostrils, and burn them immediately afterwards.

Diphtheria, like scarlet fever, whooping cough, etc., is very apt to be propagated in schools, by children breathing one another's breath, when apparently convalescent; and as attendance at Board Schools is becoming more rigidly enforced, there can be no doubt that this source of infection will increase, unless special precautions are taken.

Typhus Fever.—This disease was formerly known as spotted or jail-fever, and for many ages has been the scourge of prisons and armies, and all collections of people living in over-crowded places, with unsanitary arrangements. It is essentially a disease due to filth, over-crowding, and destitution; but when once established by these conditions, it is capable of being carried by infection to others who live amidst healthy surroundings. It generally occurs in winter, when over-crowding and the consequent foul air are most prevalent; and the first principle in preventing its spread, is to have free ventilation, even though it be at the expense of warmth. With free ventilation, the disease cannot be carried more than a few feet. Indeed, typhus fever (as well as diphtheria) patients are not uncommonly placed in hospitals in the same well-ventilated ward as twenty or thirty patients suffering from other diseases, without the spread of infection. It is important that several typhus patients should not be collected in the same room, as thus the concentration of the poison and the danger of infection are increased.

The main points requiring attention are—the isolation of the sick as far as is possible; the attendants should by preference have had typhus fever previously; the rooms should be freely ventilated by open windows and fires; all carpets, curtains, etc., should be removed and disinfected; disinfectants should be used in the room, and the excreta received into these; after convalescence the whole room thoroughly disinfected.

Relapsing Fever.—This disease was formerly common in this country, but except in some parts of Ireland has entirely died out. In Russia it is still prevalent. A peculiar Bacillus (Spirillum Obermeieri) has been found in the blood in this disease, the occurrence of which always corresponds exactly to the paroxysms of the disease.

Epidemics of relapsing fever generally follow in the track of typhus fever; and it would seem that over-crowding and filth are the special causes of the latter, while an impoverished condition

and starvation along with a continuance of the over-crowding cause the former.

Typhoid Fever.—The diseases hitherto considered are contagious, that is, can be propagated by the atmosphere surrounding a patient or by actual contact with him. Typhoid fever, cholera, and dysentery on the other hand are not so contagious, but only through the stools or vomit of the patients; which again probably never communicate infection in the fresh condition, but only after being kept a day or two. It is, therefore, essential in the treatment of these diseases, that the stools should be immediately disinfected, and got rid of at the earliest possible time.

Disinfectants should be placed in the bed-pan before its use, and an additional quantity added afterwards. In the country, it is preferable to bury the stools at a considerable distance from any source of water-supply,—earth being an excellent disinfectant. In towns they are commonly emptied into the water-closet without complete disinfection, and are carried into the sewers until defective traps or badly-ventilated drains allow the entrance of sewer gas into the house, carrying with it the specific poison; or until the water-supply becomes contaminated with sewage in the house or before its arrival there.

Wherever any danger of typhoid fever, cholera, etc. exists, ensure: (1) that the water-closets have a separate water-supply from that used for drinking purposes, and that there is no possibility of one supply being used for the purposes of the other; (2) that all sink-pipes, waste-pipes, etc., be disconnected from the drain, and the soil-pipe thoroughly ventilated; (3) that all water be *boiled* and filtered before using, and no unboiled milk be drunk.

Isolation is not necessary for typhoid fever patients; but perfect cleanliness is essential. The evacuations and all tainted clothing must be thoroughly disinfected.

The origin of typhoid fever (also known as enteric fever) is somewhat doubtful. All are agreed on one point—that it is a

filth disease; the only point in dispute being whether it can arise from unsanitary conditions alone or requires the importation of a previous case. It occurs especially where the contents of a drain or cess-pit are allowed to remain stagnant and decompose, and then obtain access to drinking-water; though whether the emanations from such a source alone suffice to cause it is doubtful (*see also pages 126 and 164.*)

"Gastric fever," "low fever," are names given to ill-defined cases of typhoid fever, and these are especially dangerous to others, as, owing to their real nature not being recognised, the evacuations are not properly disinfected.

Cholera.—Cholera, which was formerly so common, now seldom occurs in this country. In its mode of prevalance and propagation it is very similar to typhoid fever, not being contagious, except through the evacuations. The colourless watery character of these increases the risk of accidental tainting of the room; disinfectants should therefore be freely used in the room, as well as in the bed-pan; and linen and bedding should be carefully disinfected. The aerial propagation of cholera is asserted by some, and in case of an epidemic it would be wise to act as if this view were correct, carefully isolating all patients. It is certain, however, that the chief, if not the sole, mode of origin of cholera is through drinking water contaminated with the choleraic poison.

The same precautions respecting the drainage arrangements of a house should be taken, as in the case of typhoid fever; and all water and milk drunk should be previously boiled.

The same remarks apply to **summer diarrhœa,** which is nearly always due to the drinking of water containing some organic poison. Any possible contamination of water must be carefully avoided, and all water must be boiled before drinking. This is a question of great importance, as the mortality from summer diarrhœa, especially among young children, is very great.

CHAPTER XXXIX.

ISOLATION AND DISINFECTION.

Necessity for Isolation.—Legal Penalties for Neglecting Isolation or Disinfection.—Disinfectants.—Deodorants and Antiseptics.—Fresh Air and Cleanliness.—Heat and Cold.—Modes of Applying Heat.—Sulphurous Acid.—Chlorine.—Iodine.—Nitrous Acid.—Carbolic Acid.—Permanganate of Potass.—Sulphate of Iron.—Chloride of Zinc.—Chloralum.—Sanitas.—Terebene.—Charcoal.—Practical Disinfection.

Isolation.—The isolation of patients suffering from infectious diseases is of the utmost importance, in the interests of the community. This and disinfection are our only resources in preventing the spread of the contagious diseases, to which the process of vaccination is not yet applicable. It is essential that this isolation should be strictly maintained, not only in scarlet fever, small-pox, and typhus fever, but also in measles and whooping-cough, in which it is too commonly neglected.

Isolation should be maintained in every case, until the absence of infection is ensured. The sending to school of children just convalescent from infectious diseases is a common cause of epidemics. Mild cases of diphtheria may be unrecognised, and lead to the infection of other children by kissing, etc. Similarly children who have not finished peeling from scarlet fever, or who still have a slight whoop from whooping-cough are not infrequently allowed to mix with other children.

No child should be allowed to return to school after suffering from an infectious disease, without a doctor's certificate.

Certain legal penalties are incurred by those who expose themselves or their relations, while suffering from infectious diseases. Thus, if a person suffering from any dangerous infectious disorder, enters a cab or other public conveyance, without informing the driver of his condition, he is liable to a penalty not exceeding £5. Similarly, any person suffering from any dangerous infectious disorder, who exposes himself in any street, school, church, theatre, or

other public place, or in any public conveyance, and any person in charge of one so suffering, who so exposes the sufferer, is liable to a penalty not exceeding £5.

Similar penalties are involved in the neglect of disinfection. Thus, the owner or occupier of a house may be required to cleanse and disinfect any house or room, and the articles contained in it—where infectious disease has existed—under a penalty not exceeding 10/- a day, for neglect.

Any person who, without previous disinfection, gives, lends, sells, or exposes any bedding, clothing, etc., which have been exposed to infection, is liable to a penalty not exceeding £5.

Any person, who lets a house or room, in which there has been an infectious disease, without having it disinfected to the satisfaction of a medical man, is liable to a penalty not exceeding £20.

Any person, who lets or shews for hire, any house or part of a house, making a false statement as to the fact of their being then in the house, or having within six weeks previously been therein, any person suffering from an infectious disease, such person answering falsely is liable to imprisonment, with or without hard labour, or to a penalty not exceeding £20.

Disinfectants.—Disinfectants are substances capable of destroying the poison of the various fevers, acting in all probability by preventing the growth of, and killing the minute organisms to which these diseases are apparently due. The word *germicide* (germ destroyer), in a strict sense expresses the same signification. Disinfectants must be carefully distinguished from *deodorants* or deodorisers, such as charcoal, and from *antiseptics*, such as common salt. Deodorants remove foul smells,—in the case of charcoal probably by oxidation in its substance; other deodorants, like tobacco, act simply by veiling the disagreeable odour, and are not true preventives of infection. Antiseptics prevent putrefaction, and some antiseptics, like carbolic acid, have a strong disinfectant power; while others have little or none.

Disinfectants may be applied *to prevent the origin* of infectious

diseases, or *to prevent their spread.* For the former object, the best measures are an abundant supply of fresh air, and absolute cleanliness; while for the latter object, the same measures are essential, with the addition of certain special disinfectants.

The importance of an abundant supply of *fresh air* in all fevers cannot be exaggerated. It is the most important and efficient disinfectant. Typhus fever is not infectious a few feet from the patient in a well-ventilated room, but most virulently so in a closed-up room. Possibly, it is the want of oxygen that makes the sewer-gas issuing from drains so dangerous; while when sewage is freely exposed to the air, as in the case of the river Clyde, bad effects are rarely, if ever, produced. Pasteur has found in some of his latest researches, that the virus of chicken cholera becomes greatly attenuated by cultivation in a medium rich in oxygen. Exposure to fresh air of infected bedding, clothing, etc., involves not only a salutary dilution of the poison, but also oxidation and disintegration of the organic matter accompanying it, thus rendering it incapable of producing further harm.

Extreme cleanliness is another important agent in preventing the spread of infectious diseases. Most of these diseases spread more rapidly in an atmosphere containing unoxidised organic matter, —an atmosphere which is, so to speak, devitalised—all the ozone being exhausted in oxidising organic matter. The importance of cleanliness is accentuated by Dr. W. B. Carpenter's view of the origin of the contagia of infectious diseases, which we may call the natural history view. He holds that the contagia of infectious diseases are due to the progressive development of innocent germs (from the vegetable world), in conditions by which they acquire their virulent activity. Recent experiments do not confirm the accuracy of previous observations on this point (*see page 362*). According to Dr. Carpenter, the conversion from one class to the other is owing to the character of the breeding-ground; and the breeding-ground which is most apt to lead to development of virulent characters is a condition of filth and

overcrowding. This will account also for some epidemics of various fevers being much more severe than others.

The chief disinfectants in ordinary use are :—

1. *Heat and cold.*—Cold is commonly used to prevent putrefactive changes, but is not so serviceable as a means of disinfection. Cold weather often heralds the diminution or stoppage of an epidemic, the exceptional cases being explicable by the overcrowding and artificial heating of ill-ventilated rooms. De la Tour found that dry yeast might be exposed to the extremely low temperature of – 60° C. or – 76° Fahr., without being killed; in the moist state it was killed by any temperature below – 5° C. or 23° Fahr. The resistance of living matter to cold appears, however, to depend greatly on the special form of that matter. Thus, Cohn found that certain bacteria only lose their activity temporarily, when exposed for five hours to a temperature below – 10° C. or 14° Fahr., and sinking for some time to – 18° C. or – 0°·4 Fahr. (Huxley.)

Heat is one of the most valuable disinfectants we possess. A great fire has more than once caused the cessation of an epidemic, as in the Great Fire of 1666 following the Plague. The degree of heat required to destroy the germs of infection is somewhat doubtful. It is possible that the spores of Bacteria may resist a temperature which is fatal to the adult forms. Pasteur found that dry spores of yeast could be exposed without destruction to a temperature of 120°-125° C (248°-257° Fahr), while when moist, they were all killed by exposure to 100° C (212° Fahr.). "But the maximum limit of heat which living matter can resist is no less variable than its minimum limit" (Huxley). Cohn found that exposure of Bacteria for an hour to a temperature of 60°-62° C. (140°-143° Fahr.) effectually prevented their development. In many experiments it was noted that long exposure to a lower temperature than that required to immediately destroy life produced the same result as short exposure to a higher temperature (*see also page 131*).

Dr. Henry found that the activity of vaccine lymph was destroyed

by exposing it for three hours to a temperature of 140° Fahr., though at 120° Fahr. it retained its properties unaltered. The virus of scarlet fever is said to be destroyed by a temperature of 204° Fahr.; and it is probable that none of the lower infective organisms can resist a dry heat of 266° Fahr., or a temperature of 230° Fahr. when immersed in a liquid.

Three methods of applying heat as a disinfectant are in use.

1st. *Baking* the infected clothing in a hot-air chamber. This plan has proved very successful, in the disinfection of bedding, clothing, etc., when conducted with care. As it requires a special apparatus (such as Ransome's self-regulating disinfecting stove, or Scott's disinfecting chamber), it can only be carried out at some central establishment. The local authorities usually provide this, and the infected articles can be disinfected without any cost to the individual.

2nd. *Steaming* the infected clothing by means of super-heated steam is a very good plan. In ensures the interior of the bedding being raised to a sufficiently high temperature. Moist heat is efficacious in destroying the germs of disease, at a lower temperature than dry heat.

3rd. *Prolonged boiling* in water as a rule completely disinfects clothing, but it is not so satisfactory as baking. Its efficacy is made more certain by the addition of carbolic acid to the water.

A fourth plan is more efficacious than any of the three preceding, namely the *destruction by fire* of all infected articles. In poor and crowded neighbourhoods, where the bedding is of little value, this is by far the best plan; and in all cases, everything of small value should be destroyed. This especially applies to toys and books, which commonly escape complete disinfection.

2. *Sulphurous Acid* is very useful in disinfecting empty rooms; but to obtain it in sufficient strength to thoroughly disinfect an occupied room, it would be necessary to burn a quantity which would render the atmosphere of the room intolerable. It is an antiseptic as well as a disinfectant, and is very destructive to all forms of plant life. After the room is evacuated by the patient

(as after scarlet fever), the chimney and windows are closed. An iron saucepan or shovel is then taken and supported on a pair of tongs over a bucket of water. A quantity of sulphur is then placed in the saucepan and set on fire, and the room is left closed for about half a day. It is usual to allow about one pound of sulphur for every thousand cubic feet of space in the room. If the room is a large one, it is well to burn the sulphur at two or more points, in order to secure thorough diffusion of the sulphurous acid.

3. *Chlorine* is commonly used in the form of chloride of lime, which constantly evolves small quantities, and can be made to give off more by the addition of vinegar. It is doubtful whether the small amount evolved from vessels placed in the sick-room is of great value; and anything above a minute quantity produces great irritation of the lungs and coughing. It is more valuable in purifying rooms after they are empty, and in keeping water-closets sweet. When required to disinfect a room completely, it can be obtained by the addition of strong hydrochloric (muriatic) acid to black oxide of manganese, or by the addition of strong oil of vitriol to a mixture of common salt and black oxide of manganese.

Euchlorine ($Cl_2 O_4$) is also of considerable value as a disinfectant. It is generated by dropping crystals of chlorate of potassium into some strong hydrochloric acid. Like chlorine, it is very irritating to the lungs.

4. *Iodine* occurs as a flaky solid, which gradually evaporates. It is less pungent than chlorine, and not so efficacious as a disinfectant. It is useful, however, to have it in a warm place in the room on a plate, so as to allow it gradually to enter the atmosphere. In case of exposure to infection, where it is important not to carry the disease to children, it is possible to become disinfected in a few seconds by shutting oneself up in a small closet, and burning a small amount of iodine, at the same time holding the breath to prevent the irritating vapour entering the lungs.

The vapour of *Bromine* has occasionally been used as a disinfectant, but it possesses no special advantages.

5. *Nitrous Acid* is a most efficient disinfectant, when used, like the preceding, in sufficient strength. Its power of oxidising organic matter, and destroying offensive smells, is very great. Owing to the very irritating character of the fumes, however, it is only suitable for empty rooms. It is best generated by pouring strong nitric acid (aquafortis) on a copper coin or copper filings.

6. *Carbolic Acid* is one of the most valuable disinfectants we possess; and is in common use in a diluted condition as a dressing for wounds, in which it prevents putrefactive changes. It is important to remember that, like most other disinfectants, it is very poisonous, and has caused the loss of many lives by being mistaken for porter or other liquids. It is commonly employed mixed with some innocuous powder, and in this condition is much safer for common use. Calvert's carbolic powder contains 20 to 30 per cent. of the acid.

For disinfecting a bed-room, carbolic acid is used diluted with water to the extent of one in fifty. According to Dr. Baxter, below this amount of dilution it loses its disinfecting properties. It ought never to be used in the concentrated condition, as it is somewhat caustic in action. It is sprinkled about the room; the floors are washed with it; and a sheet wrung out of the carbolic solution is hung outside the door, to complete the isolation. The infected linen, etc., are steeped in it before leaving the room, and it is especially valuable for this purpose.

It is not very volatile, and is therefore not so valuable for aerial disinfection as the preceding substances; but it may be diffused throughout the atmosphere by the following plan. An ordinary house-shovel is placed over the fire until it becomes hot, but not red-hot; it is then taken into the centre of the room and an ounce of number 4 or 5 carbolic acid is poured on it.

7. *Permanganate of Potass* is usually sold in solution, under the name of Condy's fluid. It can also be obtained in crystals, and a few of these added to a quart of water give it the power of disinfecting linen, etc. It must not be used in strong solution, other-

wise it browns the linen, or the hands. It should be kept in a bottle with a glass stopper, as it rapidly oxidises. Being completely inodorous, it is very valuable in the sick-room, to add to the excreta, or to water containing soiled linen. It will not purify th atmosphere, owing to its non-volatility.

8. *Sulphate of Iron*, or green vitriol, is a valuable cheap disinfectant for some purposes. It will iron-mould linen, and must not therefore be applied, even in a weak solution, to it. As it also stains floors washed with it, its uses are limited. In solution, it may be poured into drains, or used for disinfecting heaps of manure, cesspools, etc.

9. *Chloride of Zinc* (Sir W. Burnett's disinfectant) is sold as a strong solution of the salt, and is extremely poisonous. It is a powerful disinfectant, and may be used for disinfecting closets, drains, linen, etc.; but is non-volatile, and consequently not useful for diffusion through a room. Burnett's solution contains twenty-five grains of the chloride in every tea-spoonful; when used it should be diluted with eight or ten times its bulk of water.

10. *Chloride of Aluminium*, or "chloralum," according to Wanklyn, is better and more convenient than any agent he knows for removing fœtor and effluvia, being incomparably superior to chloride of lime. It is capable of arresting putrefactive changes; and although non-volatile, and consequently not an aerial disinfectant, is very valuable for use in drains, in washing infected clothing, and in the water used for cleansing rooms.

11. *McDougall's Powder* consists of about thirty-three per cent. of carbolate of lime and fifty-nine per cent. of sulphite of magnesia, the rest being water. It is valuable for disinfecting excreta, sewage, and drains.

12. *Potassium Dichromate* and *Chromic Acid* have been recommended as disinfectants, but their high price and the stain they produce, will probably prevent their general introduction.

13. *Sanitas* has lately come into favour as a disinfectant, and as it possesses a pleasant odour, is somewhat volatile, non-poisonous,

and produces no stain, it is admirably suited for the sick-room. It is a terebinthinate product, is miscible with water, and is quite reliable.

14. *Terebene* is a hydrocarbon derived from turpentine by treatment with sulphuric acid. It has a pleasant pine-like odour, and possesses considerable deodorising powers; in both of which respects it is superior to carbolic acid. It is only slightly soluble in water; but undiluted it is a valuable deodorant for use in commodes. It is sold also in the form of powder, being mixed with other substances which greatly increase its disinfecting powers. The two chief powders are *cupralum* and *ferralum*. The former is a mixture of copper sulphate, alum, and a little potassium dichromate with terebene. It is a very powerful deodorant, and coagulates albumin, as well as neutralising sulphuretted hydrogen and ammonia. Being soluble in water it is capable of free diffusion. It has been adopted by the Government, and is largely used in the army, and for disinfecting the stools in typhoid fever and cholera.

15. *Charcoal* probably has some disinfectant as well as deodorising power. It possesses the power of concentrating in its meshes a large amount of oxygen, which is then capable of oxidising organic matter. Used as a *filter for water*, fresh charcoal oxidises some of its organic matter. It has also been employed as an *air-filter*, placed at the ventilating holes of a sewer, thus oxidising the noxious vapours; and as a *respirator* for the mouth and nose when one is exposed to offensive gases. In the last case, the gases arising in certain chemical works can be breathed without difficulty through a charcoal respirator. In all these uses of charcoal, it is essential that the charcoal should be moderately new, or recently baked.

16. *Perchloride of Mercury* in solution (1 in 1,000 to 2,000) has been shown to be one of the most powerful disinfectants.

Practical Disinfection.—1. *Of the patient.* In scarlet fever, olive oil or glycerine should be rubbed on the skin to prevent the infectious particles being scattered about the room. The expectoration should be received in a spittoon containing one

of the many disinfectants named. The stools and urine, likewise, should be received in a vessel containing half-a-pint of weak carbolic solution; or of a solution of sulphate of iron, two pounds to a gallon of water; or of Burnett's fluid, one in from four to eight of water; or some other disinfectant. Before removing them from the room more strong disinfectant should be added.

When a patient dies of a very infectious disease, such as scarlet fever or small-pox, the body should be washed with a strong carbolic solution, and placed in the coffin as early as possible, cupralum or McDougall's powder being sprinkled freely in the coffin at the same time. Burial should take place without delay; and if the body linen is not buried with the body, it should be destroyed by fire.

2. *The nurse* should preferably have had the disease previously, and should avoid all unnecessary contact with the patient. Her dress should not be woollen, but of some other washing material, such as glazed cotton. No visitors should be allowed in the room, even though they have had the disease, as they are very apt to carry it to others.

3. The *food* should not be kept in the room, and no food must be allowed to return to the kitchen. All cups, plates, etc., leaving the room, must first be dipped in weak Condy's fluid.

4. The *bed- and body-linen* must be disinfected in the room. This is best accomplished by putting them in boiling water, to which some strong disinfectant has been added, and allowing them to soak for a considerable time. Towels and pocket-handkerchiefs must be similarly treated; and rags which can be immediately burnt after use are preferable to handkerchiefs. The linen should never be sent to a laundry, as this is a common mode of spreading disease.

5. *The room* should be freely ventilated, though the patient must be protected from direct draught. All unnecessary furniture, curtains, bed-hangings, and carpets should be removed at the commencement of the illness. The floors should be washed

frequently with a solution of cupralum, or sanitas, or carbolic acid. Isolation of the infected room from the rest of the house must be strictly enforced. The utility of aerial disinfectants in the room during its occupation is somewhat doubtful, but weak chloride of lime, iodine, or small towels wrung out of carbolic solution, may be placed about the room, in addition to the essential sheet wet with carbolic solution outside the door.

6. *Uninhabited rooms* are best disinfected by washing all the furniture with a solution of chloralum, 3 or 4 ounces to a gallon of water, or with strong carbolic solution. The floor and woodwork may be washed with a similar liquid, and the paper removed. Subsequently sulphur is to be burnt in the closed room, as already described; and after a few hours, the windows thrown open, and the room allowed to remain unoccupied for a few days. Then the ceiling should be white-washed, the wall re-papered, and all the wood-work washed again with disinfectant liquid.

7. The *clothing, bedding, etc.*, should in all cases be disinfected by being exposed for an hour or two to a dry heat of 240° to 250° Fahr., or to super-heated steam.

8. *Water-closets, sinks, etc.*, should be systematically disinfected, when any infectious disease is prevalent, and especially if there is a case in the house. If there is a bad smell in the house, it is important, however, not to trust to the use of such deodorising agents, to the exclusion of an examination of drains, and a removal of sanitary defects. Similarly with regard to cess-pits and midden-heaps, it is better not to allow their accumulation, than to have to adopt measures for their disinfection. When necessary, they may be disinfected by a solution of cupralum or chloralum (1lb. to a gallon of water), or of copperas (3lbs. to a gallon of water). Solutions of chloralum, carbolic acid, terebene, or sanitas, may be used for sinks and closets.

9. *Streets and Courts* may be disinfected, where necessary, by Burnett's fluid, chloride of lime, McDougall's salts, or Cooper's salts (chlorides of magnesium, sodium, and calcium).

CHAPTER XL.

POISONING, SUFFOCATION, FITS, UNCONSCIOUSNESS.

Symptoms leading one to Suspect Poisoning.—Varieties of Poison.—General Indications for Treatment. — Antidotes. — Antidotes for the Chief Poisons.—Causes of Suffocation.—Treatment of Suffocation.—Drowning: Methods of Restoring.—Fits.—Unconsciousness.

Poisons are substances which are capable of destroying life, otherwise than by means of heat, electricity, or mechanical means. This definition will exclude such substances that may be swallowed, as pins or boiling water. The effect of poisons on the system is produced either by *chemical action* on the tissues, as when oil of vitriol is swallowed; or by *physiological action* on the system after absorption into the blood, as in the case of opium or strychnia.

Symptoms leading one to Suspect the Administration of Poison:—

1. *The sudden onset of symptoms in a person previously healthy*, these symptoms rapidly progressing to a fatal termination. This is not always a certain indication, as (1) many diseases have a sudden onset, and closely simulate the effects of poison. This is the case in regard to cholera, and several fevers. (2) Poisons may be slow in action, the symptoms only developing gradually. Arsenic, corrosive sublimate, or phosphorus, for instance, may, if only small and repeated doses are taken, produce their effects somewhat insidiously; but even here, as a rule, the next indication will hold good.

2. *The symptoms probably are noticed soon after taking a certain medicine or food*, the poison having been introduced into these. But occasionally (1) poisons are given otherwise than by the mouth; thus, chloroform may be inhaled, and morphia inserted under the skin by a small syringe. (2) Symptoms resembling those produced by a poison may arise after taking food or medicine, from some other cause. Thus, unwholesome food may produce violent symptoms; and a copious draught of cold water, when overheated, has been known to produce death.

3. *If more than one has partaken* of the suspected food, they

will all suffer from similar symptoms; thus helping one to identify the cause.

In all cases of suspected poisoning, it is important to preserve the vomited matters and excreta, and to safely lock up all food or medicine, part of which has been given to the patient.

Classes of Poisons.—Three are commonly described—irritants, narcotics, and narcotico-irritants, combining the properties of the other two. A more accurate classification is into—

1. *Corrosive poisons*, as strong mineral acids, caustic alkalies, oxalic acid, corrosive sublimate, zinc chloride (in Burnett's disinfecting liquid). These destroy the mucous membrane of the alimentary canal, producing ulceration, and even perforating through the stomach or intestines.

2. *Irritant poisons*, such as arsenic, copper and tin salts, phosphorus, iodine, cantharides, etc., act less violently than corrosive poisons—as a rule, producing inflammation without ulceration. They cause thirst and pain in swallowing, vomiting, abdominal pain, followed by diarrhœa and other symptoms. All these symptoms occur in an aggravated form in corrosive poisoning.

3. *Narcotics and narcotico-acrids* may be divided into—

(1) *Poisons producing sleep*, as opium, and large doses of alcohol, ether, or chloroform. There is great drowsiness, followed by heavy sleep, from which it is difficult to rouse the patient, and finally a condition of coma (complete insensibility), passing on to death.

(2) *Poisons producing excitement or delirium*, such as belladonna, stramonium, hyoscyanus, Indian hemp, and alcohol and ether in smaller doses than are required to produce sleep.

(3) *Poisons producing convulsions*, especially strychnia.

(4) *Poisons killing by shock* to the nervous system, as prussic acid.

(5) *Poisons producing suffocation*, as coal gas, carbonic acid, carbonic oxide, sulphuretted hydrogen, sewer gas, etc.

General Treatment in Cases of Poisoning.—The indications

in every case are to—1. *Get the poison out of the system as quickly as possible.* The two chief measures with this object are the use of emetics and the stomach-pump. In cases of chronic poisoning, as from lead, remedies promoting elimination from the kidneys are required, but the prescription of these devolves on the medical attendant.

Emetics must not be used in every case of poisoning. Thus where a strong mineral acid or caustic alkali or oxalic acid has been swallowed, an emetic would only aggravate the symptoms, and increase the danger of injury to the walls of the stomach. In these cases the first indication is to neutralise the poison. But in poisoning by alkaline and earthy salts, by phosphorus, arsenic, lead or copper salts, opium, belladonna, etc., emetics are indicated immediately. In the absence of sulphate of zinc, which is the best emetic (in half drachm doses), give a tea-spoonful of mustard in a table-spoonful of water, and repeat the dose every quarter of an hour until free vomiting is produced. This may be aided by tickling the back of the throat, and by copious draughts of warm water.

The *stomach-pump* is used by a medical man, who ought to be sent for immediately in any case of poisoning. Its use by an unskilled person would not be free from risk.

2. *Neutralise the effects of any poison you cannot remove.* In the absence of a medical man, it is important to know certain simple remedies to give after the adminstration and action of an emetic. These are known as **antidotes**, and there are three kinds of them, only the first two being within the reach of the unskilled.

(1) *Mechanical antidotes*, such as flour and water, magnesia, a mixture of chalk with castor oil and water. These prevent the irritating action of the poison, and so give time for the administration of other remedies. Thus they are useful, for instance, in phosphorus or cantharides poisoning. Animal charcoal is especially valuable in poisoning by strychnia or morphia, keeping them in suspension and preventing their entry into the circulation.

(2) *Chemical Antidotes.*—In the use of these it is important that the antidote should be inert, and incapable itself of doing damage; also that the compound produced by the action of the antidote on the poison should be insoluble in water, and if possible insoluble in the digestive juices. For acids chalk and magnesia are the best antidotes; better than soda or potash, as the latter may form soluble compounds. Thus, if one gave carbonate of potash in oxalic acid poisoning, binoxalate of potash (salts of sorrel) would be produced, which is soluble in water, and almost equally poisonous with oxalic acid. For poisoning by caustic alkalies, lemon-juice or vinegar is the best antidote; for poisoning by lead or barium salts, alkaline sulphates,—these forming insoluble sulphates of the poisonous metals. For corrosive sublimate, the white of egg is the best antidote, an insoluble albuminate of mercury being formed; for opium poisoning, tannic acid acts with some little efficiency as a chemical antidote.

(3) *Physiological Antidotes.*—Different drugs have opposite effects on the circulation, or respiration, or nervous system, and this may be utilised in poisoning. Thus, belladonna is a partial antidote to opium; Calabar bean a complete antidote to strychnia. It is important to remember that the antidote in these cases may destroy life equally with the original poison, if in excess.

3. *Combat the individual symptoms that may arise.*—With this object in view, after emetics and antidotes have been administered, it may be necessary to give stimulants where there is collapse; strong coffee or tea where great drowsiness occurs (as in opium poisoning), and opium in cases where there is great pain. These and other remedies ought in all cases, where possible, to be given under the direction of a medical man.

Antidotes for the chief Poisons. *Alkalies* (caustic potash, soda, or lime).—Do not use emetics or stomach pump; give vinegar and water or lemon-juice at once; then administer olive oil (thus converting the alkali into a soap), and plenty of milk.

Antimony (tartar emetic and butter of antimony). If vomiting

not already present, induce at once. Then give anything containing tannin, such as strong boiled tea or nutgalls, followed by draughts of milk.

Arsenic (chiefly white arsenic, a tasteless powder). Induce vomiting at once; after this give a mixture of milk and raw egg; sugar and magnesia in milk is also useful. Subsequently salad or olive oil may be given, and stimulants to counteract collapse.

Salts of Lead (sugar of lead, paint, etc.)—Give an emetic, and follow this with a dose of Epsom salts, which forms an insoluble sulphate of lead.

Salts of Mercury (especially corrosive sublimate).—Encourage vomiting, then give white of egg in plenty of milk.

Phosphorus (matches, rat poison, etc.)—Encourage vomiting by emetics and large draughts of warm water; then give large doses of magnesia or chalk in water. Avoid any oily or fatty matters, as they dissolve phosphorus, and so aid its absorption.

Mineral Acids (oil of vitriol, aqua fortis, spirit of salt).—Do not waste time in giving emetics, but proceed at once to administer chalk and water, or better still, calcined magnesia. If these are not obtainable at once, then whiting or wall plaster will answer the purpose.

Oxalic Acid.—Never begin by using the stomach pump or giving emetic draughts; but give at once large quantities of chalk or magnesia in milk. If, after this, there is no vomiting, an emetic may be administered. The advice is good to "scrape the ceiling and administer the scrapings, if you can get nothing else."

Prussic Acid.—There is no time for emetics or possible antidotes. Dash cold water over the head and face and back; then rub the skin until warm and dry, and repeat the douche. Artificial respiration may be carried on at the same time. Hold strong smelling-salts to the nostrils, and, if obtainable, fresh chloride of lime held near the mouth is valuable. Brandy and sal volatile internally are useful, swallowed if possible, or injected into the bowel. It is important to remember that the oil of bitter almonds, largely used

in the kitchen for flavouring, contains a considerable amount of prussic acid.

Carbolic Acid is not uncommonly swallowed by mistake. Give at once an emetic of mustard and water; then uncooked eggs *ad libitum*, followed by olive oil, or better still, a mixture of olive and castor oil, with magnesia. The administration of stimulants is necessary, as collapse soon occurs.

Chloral hydrate poisoning is usually the result of an accidental overdose, taken to produce sleep, and is generally not discovered for some hours, if at all during the patient's life. If discovered early, give an emetic; if later, give stimulants freely, and perform artificial respiration.

Strychnia.—The stomach-pump, used while the patient is under the influence of chloroform, is the proper treatment; but failing the possibility of this, emetics should be given, followed by a large dose of powdered animal charcoal. The antidotes are chiefly medicinal, and ought to be given by a doctor; but in the absence of the latter, an injection into the bowels, containing half a small teaspoonful of laudanum with brandy and milk, is justifiable.

Opium or morphia.—Give emetics at once. Then apply a cold douche to the patient's chest and head, to thoroughly rouse him. After this, keep him walking about between two men, not allowing him to lie down on any account. If he is in a condition of profound unconsciousness, with slow breathing, artificial respiration is advisable, and the free use of the galvanic battery. Strong coffee is a useful adjunct to the treatment.

Poisonous gases (chloroform, coal-gas, etc.) Carry the patient into the open air, and carry on artificial respiration persistently for at least half an hour, if no sign of returning breathing.

Suffocation.—Suffocation may result from various diseases; but, independently of these, it is occasionally the result of attempted suicide or murder, or of accident. In these cases it is highly important to know exactly what to do, and to do it without a

moment's delay. In all forms of suffocation breathing is impeded, and probably stopped, and the circulation of blood through the lungs and right side of the heart is brought to a standstill. The three main indications are—(1) to induce the natural process of breathing; (2) to keep the heart going; and (3) to keep up the temperature of the body. Artificial respiration, ammonia to the nostrils, and a cold douche to the head and neck, are the means to gain the first end; warm applications over the heart, galvanism, and friction to the extremities for the second; while hot bottles or hot bricks and blankets, with the aid of friction, meet the third indication.

When a person is found *hanging*, it would appear obvious that the first thing to do is to cut him down; but many a life has been lost by the finder of the suicide first running for help. Next remove all tight clothing from the neck and chest, and commence and persevere for a considerable time with artificial breathing, as described for drowning.

Strangulation generally means murder; while hanging (except in the case of executions) nearly always is suicidal. The treatment is similar to that for hanging. Remove all constrictions from the neck, perform artificial respiration, rub the extremities, and apply hot bottles. These things cannot all be done by the same person; but, whatever else is neglected, in all cases of suffocation (including apparent drowning) artificial respiration ought to be kept up without any interval.

Suffocation is occasionally produced by *some foreign body pushed into the throat*, accidentally or with a murderous intent. Here the first thing in treatment is to remove the substance, if it can be reached; or, if this is impossible, send for a medical man with the greatest haste, as opening the trachea below the throat may be necessary in order that breathing may occur through an artificial channel.

Smothering is not uncommonly produced by the *over-laying of children*. This chiefly occurs between Saturday and Monday,

when the parents are intoxicated. According to the Registrar-General, almost one case a day happens in London alone.

Suffocation is occasionally due to *poisonous gases*. Occasionally sewer-gas has been the cause; more commonly the carbonic acid gas accumulating at the bottom of wells or near limekilns. Sometimes a leakage of coal-gas has occurred in bed-rooms, and their occupants have been found dying or dead in the morning. In all such cases, immediately remove the patients into the open air, commence artificial respiration, and carry it on even after it seems quite hopeless; at the same time, adopting measures to stimulate the heart and keep up the temperature.

Drowning is the most important instance of suffocation, and the one in which it is most essential that every one should know how to proceed in attempting restoration. The indications are to *restore the breathing*, and *promote warmth and circulation of blood*. Do not waste time in running for help; but after removing all clothing from the chest and arms, commence artificial respiration. Hanging up by the heels and all other rough methods are strongly to be condemned.

The rules are—1st. Cleanse the mouth and nostrils from any foreign matters (such as weeds or mud); draw forward the tongue, and keep it forward by means of an elastic band over the tongue and under the chin, or let some one hold it forward.

2nd. Place the patient on his back on a flat surface, having a firm cushion (or folded coat) under his head and shoulders.

3rd. Grasp the patient's arms just behind the elbows. Draw them over above the head, keeping them so for two or three seconds. Then reverse the manœuvre for about the same length of time, pressing the arms firmly against the sides of the chest.

4th. Repeat the movements with the arms steadily and perseveringly fifteen times in a minute, at regular intervals, taking care not to perform them hurriedly. It is convenient to have some one at hand to time the movements; the common error is to exceed the above number of movements per minute, and then they are not so efficiently executed.

Pulling the arms above the level of the head, expands the chest, and a partial vacuum being produced in the lungs, air rushes in to supply its place; pressing the arms against the chest, imitates the natural process of expiration.

The above movements should be persevered in, until natural attempts at breathing occur, or for more than half-an-hour even when there is no apparent return to life.

At the same time, attempts to *excite respiration* may be made by someone else, though these should never interfere with the steady performance of artificial respiration. Such means are—tickling the throat with a feather, or exciting the nostrils with snuff or smelling salts. Another operator may be engaged in procuring dry and warm blankets, and in rubbing the legs upwards towards the trunk firmly and steadily; the friction to be carried on under warm blankets. As soon as the patient is sufficiently recovered, small quantities of warm brandy and water or coffee should be given, and large mustard poultices over the chest will often relieve the distressed breathing.

Fits.—Fits are most commonly due to epilepsy or hysteria; but occasionally they are due to drunkenness, insanity, apoplexy, or other causes. The immediate treatment in all these cases is somewhat similar. The convulsions may result in severe injury to the patient; it is important, therefore, to prevent him from falling into the fire, or into water, or against any hard and sharp object. Those who are subject to fits should be carefully watched and tended between the attacks. In the fit itself, the tendency is for the breathing to be impeded, and the patient becomes blue and livid. Remove all tight ligatures from the neck and chest, and if the fit is prolonged, it will be useful to help breathing, by the performance of artificial respiration. Occasionally, the tongue is bit severely during the fit; it is advisable, therefore, to put a spoon between the teeth to prevent this; and if there are any artificial teeth, care should be taken to prevent the patient swallowing them.

Hysterical fits are nearly confined to women, and chiefly those of an emotional temperament. In these attacks the patient is certain not to injure herself, and may be allowed to fall where she likes. The application of a cold douche to the head may assist her return to consciousness, or, better still, a good shock from a galvanic battery. Where it is not certain (from the screaming accompanying the fit, or the previous history), that the attack is hysterical in character, it is preferable to treat it as one of the more serious forms of fit, until there is time for enquiry.

Epilepsy is occasionally *feigned* in order to obtain alms, etc. In the true epileptic attack there are three stages. In the first the patient is pale and completely rigid; in the second there are convulsions (jerkings), accompanied with lividity and dilated pupils; in the third the patient lies quiet and unconscious for a varying period. Impostors generally overact the convulsions and become heated at once. They never fall so as to hurt themselves; and their eyeballs cannot be touched without making them flinch.

Unconsciousness.—A person may be found in the street in an insensible condition. It is highly important to know what may cause this, as many more serious cases of insensibility have been mistaken for drunkenness. It must also be remembered that a drunken person may suffer from some of the other causes of insensibility; and that, before he is carried to the police-station, it is well to ascertain the absence of these. Many unconscious people have been locked up for the night, on the supposition that they were *drunk*, when, as a matter of fact, they were *dying*.

The chief causes of unconsciousness are:—1. *Drunkenness.* Here there is the odour of liquor in the breath (but there may be this in the other cases); the patient can usually be roused, and talks incoherently. In this case give an emetic, and apply warmth to the extremities. 2. *Apoplexy.* The arm on one side of the body falls more helpless when raised than on the other; the breathing has a peculiar snoring character. Raise the head; undo the clothing around the neck; procure medical aid at once.

3. *Epilepsy.*—The patient may be found unconscious after an epileptic attack. It is only necessary to keep him quiet and warm.

4. *Syncope or Fainting.*—Lay the patient on his back, and raise his legs so as to help the flow of blood to the head. Half a teaspoonful of sal-volatile to be given in water as soon as the patient can swallow it. 5. *Shock* from fright or grief, lightning, etc.—Help the restoration of circulation and warmth, and give small quantities of stimulants cautiously. 6. *Injuries to the Brain*, as concussion, fracture of skull, etc.—Place the patient in a dark quiet room; apply warmth to his body and limbs, and do not give any stimulants. 7. *Uræmia* (blood-poisoning from kidney disease) may simulate the symptoms of apoplexy or opium poisoning, if the patient is found in the streets. It is essential, therefore, in all cases to procure the attendance of a medical man. 8. *Opium or Morphia Poisoning.*—The treatment of this condition has been already described. The means of distinguishing it from the other causes of unconsciousness are often very difficult, especially in the absence of any history.

CHAPTER XLI.

WOUNDS, HÆMORRHAGE, BURNS, AND SCALDS, BITES AND STINGS.

Varieties and Treatment of Wounds.—Varieties and Treatment of Hæmorrhage.—Means of Arresting Arterial Hæmorrhage.—Burns and Scalds: Immediate Treatment.—Treatment of Bites and Stings.

Wounds.—Cuts or wounds require immediate treatment, especially when deep or extensive, and it is important that what is done before a medical man arrives should not be injudicious, and require doing over again.

The chief varieties of wounds are *incised wounds*, in which there is a clean cut; *contused wounds*, in which bruising accompanies the cut; *lacerated*, where the parts are torn; *punctured*, where the wound is small, but probably penetrates deeply.

1. In all cases it is important, first of all, to *remove all coverings*

from the wound, and ascertain its exact condition. Do not be deterred by the presence of free bleeding: even when this occurs it is better to expose the wound to the air for a short time.

2. Next *wash the part carefully* with clean cold water. This tends to diminish bleeding, and at the same time removes dirt or bits of clothing, etc., from the wound. Where the wound has closed, pull its edges apart, to make sure that no dirt is secreted between them.

3. *Arrest the hæmorrhage* if possible. The treatment of this will vary according to circumstances (see next section); but do not try to arrest it by a multiplicity of bandages. These simply, in severe cases, hide the bleeding without stopping it.

In the treatment of incised wounds, after washing the wound, the hæmorrhage usually ceases naturally on bringing the edges together. The edges are fixed together most conveniently by narrow stripes of adhesive plaster, applied transversely at intervals if the wound is long. Over this a strip of linen wrung out of cold water is wrapped, and not allowed to become dry. It is important to place the patient in an easy position so as to avoid straining the wound; and the part should be carefully kept at rest. If the wound is in the cheek for instance, speaking and mastication should as far as possible be prevented; if in the leg no walking must be allowed, etc.

Contused and lacerated wounds are more difficult to heal, owing to the more severe injury to and irregularity of the edges of the wound. In these cases, as for incised wounds, the indications are to wash carefully and remove all foreign matters; to arrest the hæmorrhage, and replace the parts as far as possible in their natural position; afterwards applying carbolised cold water bandages. In the after-treatment of all wounds, and especially contused and lacerated wounds, it is highly important to keep the wound "sweet" and free from decomposition; for this purpose the best dressing is pieces of lint dipped in a solution of carbolic acid, one in sixty of water.

Punctured wounds are frequently dangerous, owing to their penetrating deeply, and occasionally injuring important vessels or internal organs. Examine the wound carefully, to discover if any clothing or other foreign matter has been driven in; if so, remove it where possible. Then wash the wound carefully with carbolic lotion, and keep the injured part completely at rest.

Occasionally wounds may be complicated by the protrusion of internal organs, as when a wound in the abdomen occurs. If a doctor is not quickly obtainable, wash the protruded part carefully with warm water, and push it gently into the cavity of the abdomen, unless it seems irretrievably injured.

Hæmorrhage.—Hæmorrhage, or bleeding, is the result of rupture of a blood-vessel. The *rupture* may result from a wound, or disease of the walls of a vessel, or a sudden strain. It may be *external*, from the surface of the body; or *internal*, from the lungs, stomach, etc.

There are three kinds of blood-vessels, and corresponding to these, there are three varieties of hæmorrhage—arterial, venous, and capillary. In *capillary hæmorrhage* there is simply a general oozing of blood from the injured surface, and it speedily ceases on compression, or when the wound is closed.

In *arterial hæmorrhage* (1) the blood comes out in intermittent jets, corresponding to the contractions of the heart; and (2) it is of a bright scarlet colour.

In *venous hæmorrhage* the blood (1) flows slowly, in a continuous stream; and (2) is of a dark purple hue.

Arterial bleeding is by far the most dangerous form, and not a moment ought to be lost in treating it. In the interval before a medical man arrives, one must be prepared to adopt the necessary measures, as otherwise a valuable life may be lost. The treatment will differ somewhat according as the wound is situated in the trunk or in one of the extremities; but the general indications are these:—

1. Expose and examine the wound. Nothing more embarrasses

the treatment than a number of superfluous wrappings. These should at once be removed, and the exact source of bleeding ascertained.

2. Wash the wound with cold water. If the artery is a very small one, this may even stop the bleeding.

3. Elevate the bleeding part, so as to diminish the flow of blood to it. If the wound is in the palm of the hand for instance, the arm must be held aloft.

4. Apply pressure so as to control the flow of blood through the wounded vessels. This may be accomplished (1) By pressing with the two thumbs directly over the point in the wound, from which the blood is seen issuing in spurts.

(2) By applying a small pad made of linen folded into a compact lump over the bleeding point, and tying a bandage tightly around the limb, in order to keep it in position. This is successful in many cases, but as a rule not so good as direct pressure by the thumb over the bleeding point, kept up until a surgeon arrives.

(3) By pressure on the main artery *on the heart side* of the bleeding point. There are certain main trunk arteries which carry the blood to the four limbs. If one of these is wounded the hæmorrhage is very severe, and unless at once controlled, will prove speedily fatal. The best way to control it, is to compress the artery higher up in the limb. Similarly if a branch of an artery is wounded, the bleeding is best controlled by compressing the main trunk. The main trunk can be more easily compressed than any of its branches owing to its great size, and compression of a branch is often ineffectual owing to the anastomoses or communications between several branches. In exerting pressure on an artery it is always best to choose a point where the artery can be pressed against some bone as a point of resistance. Thus when there is a wound in the forearm or hand, the best point to control the hæmorrhage is about the middle of the upper arm, where the trunk artery can be pressed against the inner side of the humerus (arm bone). Similarly in any dangerous bleeding from the leg, the best point of pressure is at the bend of the groin.

(4.) Another form of pressure which is useful, and in slighter cases of bleeding may suffice, consists in bending as much as possible the joint above the wound, so as to diminish the flow of blood into it. Thus, by bending the elbow as much as possible, a severe bleeding from the forearm or hand may be greatly diminished; by flexing the knee to its utmost, bleeding from the leg or foot may similarly be diminished. This mode of compressing the trunk arteries must not be relied on, but is useful in conjunction with other measures.

Compression of the trunk artery higher up than the wounded point is best exerted by the thumb over a point where the beating of the artery can be felt near some bone. The thumb is placed firmly over the artery, and pressed towards the bone; while the thumb of the opposite hand is placed over its fellow, in order to steady it.

Compression of the trunk artery may also be exerted by a tourniquet, which is an instrument exerting pressure at one point, and fastened round the limb. An imitation of this may be improvised by taking half of a large cork, wrapping it in a handkerchief, and after placing it over the artery above the bleeding point, tying it firmly in its place by means of a bandage round the limb.

5. Other means of arresting arterial hæmorrhage, such as tying the wounded artery, and the application of substances (called styptics) to the wound to arrest hæmorrhage, are best left to medical men. The application of ice to the wound is useful in the less severe forms of hæmorrhage. It may be washed also with weak vinegar and water, but in the severest forms of hæmorrhage this would be ineffectual, while in the less severe forms it would be unnecessary. It is better to trust to pressure over the bleeding point, or at a higher part of the limb.

Venous bleeding may occur along with arterial or by itself. As most of the arteries are deeply placed, a superficial wound is more likely to divide veins than arteries. It is important in treating severe hæmorrhage from veins to remember *the direction of*

the circulation in veins, which *is towards the heart.* It is evident, therefore, that pressure on the vein nearer the heart than the wound, by retarding the flow of blood from the wound, would simply increase the hæmorrhage. The indications in treating venous hæmorrhage are—(1) To expose and examine the wound; (2) to wash it well in cold water; (3) to elevate the limb, so as to aid the flow of blood from the wound and diminish the flow to it; (4) to apply a pad and bandage over the wound; (5) to remove any pressure or obstruction to the circulation, such as tight clothing on the heart side of the wound, except where arterial bleeding accompanies the venous.

Dangerous venous bleeding sometimes occurs from varicose (that is, enlarged and dilated) veins of the leg, or from ulcers in the same situation. It can be immediately stopped by elevating the limb, and applying a pad over the bleeding point, firmly fastened by a bandage round the limb.

Capillary bleeding is easily controlled, usually ceasing when the edges of a wound are brought together, and compressed by the dressing. The application of iced water or weak alum and water may be occasionally necessary.

Internal hæmorrhage is much more difficult to treat than external. The forms most commonly occurring are bleeding from the nose, stomach, or lungs. In all these cases, keep the patient perfectly quiet; give him iced drinks, and ice to suck; and direct him to avoid coughing, so far as possible. For bleeding from the nose, apply an ice-bag across the forehead, and syringe the nose out with a strong solution of alum in iced water. If these measures fail—and in all severe cases other measures are required—a surgeon ought to be sent for. In vomiting or coughing of blood, maintain perfect quiet, give ice to suck, and iced drinks, and obtain medical help at once.

Burns and Scalds.—A *burn* is caused by the application of some substance in actual combustion, or capable of acting chemically, to the skin. A *scald* is produced by hot or boiling liquids. Its

severity varies with the character of the liquid and its temperature. Thus boiling oil produces much more severe injury than boiling water.

There are different degrees of burns and scalds, according to the amount of injury produced. In the first degree, the skin is simply reddened; in the second a blister is produced; in the third a part of the true skin (cutis) is likewise destroyed; in the fourth it extends to the subcutaneous tissues; and in the fifth and sixth the muscles and even the bone is charred.

The treatment of burns and scalds will vary considerably with their severity; but we may divide it into two parts—*constitutional* and *local*. As regards the constitutional treatment, the only matter coming under the treatment of the non-professional friend, is to diminish the primary collapse and prostration which may prove fatal in severe cases, by giving a warm stimulant immediately, and applying warm bottles to the limbs. It is important to remember (especially in the case of children), that a burn or scald on the trunk is much more dangerous than one of equal size on a limb, and that an extensive superficial burn or scald is much more dangerous than a small though deeper one.

In the local treatment (1) remove the burnt clothes immediately, and as gently as possible, so as to avoid pulling off the skin with them.

(2) Soak strips of linen in a mixture composed of equal parts of linseed or olive oil and lime-water, and apply these over the wound, covering the whole with a sheet of cotton-wool, fastened on by bandages.

If no lime-water is obtainable, then simple olive oil will answer the purpose, and is preferable to dusting any powder on the wound.

(3) Place the burnt part in such a position, that deformity will not result from the occurrence of contractions. In severe cases this is often difficult to avoid. Suppose the burn is on the front of the forearm, for instance, the skin becomes contracted as

it heals, and the arm cannot be extended. This would not have resulted if the elbow had been fastened in the extended position. Similarly, the head may become permanently pulled to one side by a scald on one side of the neck, unless great care is taken.

Bites and Stings.—*Stings of insects*, as of bees, wasps, mosquitoes, gnats, though painful, seldom produce any serious trouble; yet occasionally they have been fatal, by inducing erysipelas; or by the great irritation resulting from a large number of stings, as from a swarm of bees; or owing to the character of the part stung, as the eye, or the interior of the mouth or gullet (from swallowing a bee in a piece of honeycomb). The venom of the mosquito is specially powerful and irritating.

The irritation may be relieved by applying an alkaline lotion, such as weak ammonia (liquor ammoniæ) or soda, or rubbing the part with olive oil. In the case of wasps or bees, if the sting has been left in the wound, it must be removed before the alkali is applied.

The irritation from *nettle-stings*, (which is due to formic acid), is similarly best relieved by the application of an alkali to the affected part.

Snake-bites are seldom fatal in England, the adder and viper not possessing a sufficiently strong poison to kill a healthy adult. In the more severe poisoning resulting from the bite of the rattlesnake, cobra, etc., the only hope of success lies in treating the case immediately. It is all-important to prevent the poison from the bite reaching the general circulation. Tie a bandage round the limb at a higher point so tightly as to prevent all circulation through it; Next push a red-hot iron or cinder into the wound in order, if possible, to destroy the poison at its point of entry. Then allow bleeding to occur freely from the wound, helping it by friction of the limb. Washing the wound out with a strong solution of permanganate of potash (Condy's fluid) has also been recommended.

Bites of Rabid Animals.—Bites of rabid animals are only followed by hydrophobia when the skin is penetrated, and then six

weeks usually elapse before any symptoms appear. Hydrophobia may also result from a dog licking its master's hand or face, if the skin be cracked or sore, even though the dog is only suffering from the premonitory symptoms of rabies, which may not be characteristic. On the other hand, only a very small proportion of the bites of rabid animals result in hydrophobia, owing to the fact that the legs are usually bitten, and the saliva gets wiped off the teeth before the latter penetrate the skin. The bites of rabid wolves or cats are much more dangerous, as these generally fly to the throat or face.

There is, unfortunately, no cure known for hydrophobia; our exertions are confined to preventing it. Remembering that only in a small minority of cases does hydrophobia result from the bite of a rabid dog, one may reasonably encourage the patient. *Immediately* the bite has been received, a ligature should be tied round the limb at a higher point, so as to obstruct the venous circulation; and bleeding should be encouraged by friction and bathing the wound with warm water. Then the wound should be enlarged with a sharp pocket-knife to the depth of a quarter of an inch, and strong carbolic acid inserted into every part of it. This is better than lunar caustic (nitrate of silver), which forms a superficial film and does not penetrate deeply.

CHAPTER XLII.

TRADE NUISANCES.

Many occupations are the source of considerable danger to the workers engaged in them. They are chiefly injurious by the inhalation into the lungs of some foreign agent, which produces serious local inconvenience and irritation, and may be also absorbed into the circulation and produce more remote effects.

The injurious agents may be classified under four heads:—

(1) Insoluble particles or dust.

(2) Soluble or partially soluble substances.

(3) Injurious gases or vapours.

(4) Effluvia from offensive trades.

It is evident that, as regards the effluvia named under (4), they might generally be included under the three previous heads, though it is convenient for our present purpose to keep them separate.

The occupations in which *dust* and soluble substances are productive of injurious effect are very numerous. They have already been fully described, pages 147 to 152.

Injurious gases and vapours have received consideration on pages 157 and 158. The special offensive trades still require attention.

Offensive Trades.—It will be convenient first to state the legal enactments relating to offensive trades. By sect. 112 of the Public Health Act, 1875, any person who, after the passing of this Act, establishes within the district of an urban sanitary authority, without their consent in writing, any offensive trade; that is to say, the trade of—

Blood boiler, or	Soap boiler, or
Bone boiler, or	Tallow melter, or
Fellmonger, or	Tripe boiler, or

any other noxious or offensive trade, business, or manufacture,

shall be liable to a penalty not exceeding fifty pounds in respect of the establishment thereof, and a penalty not exceeding forty shillings for every day on which the offence is continued.

These provisions cannot be enforced in rural districts without the assistance of the Local Government Board.

The "other noxious or offensive trades," in order to be brought within the operation of the section, must be analogous to those which are specially enumerated. Thus in the case of a business of *frying fish* for sale by retail, the quarter sessions, on appeal against a conviction, found that the business, as carried on by the respondent, was an offensive trade; but were of opinion that fish-frying was not a trade which was either specified in the section,

or covered by the general words, 'other noxious,' etc. They therefore quashed the conviction. This conclusion was confirmed on further appeal.

The most exhaustive and authoritative report on this subject is by Dr. Ballard, a medical inspector of the Local Government Board, and a large portion of the information given hereafter is derived from his report.

We may consider (1) the extent to which the public is inconvenienced by various effluvium nuisances. The majority of the nuisances arise from trade processes in which animal matters are chiefly used. Perhaps the most disgusting are the effluvia from gut-scraping, and the preparation of sausage skins and catgut, the preparation of artificial manures from 'skutch' (the refuse matter of the manufacture of glue), the manufacture of some kinds of artificial manures, and the melting of some kinds of fat. Manufacturing businesses dealing with vegetable substances are often offensive, but rarely give out disgusting effluvia. The most offensive vegetable effluvia are probably those thrown off during the heating of vegetable oils, as in the boiling of linseed oil, the manufacture of palmitic acid from cotton oil or palm oil, the manufacture of some kinds of varnish, the drying of fabrics coated with such varnishes, and the burning of painted articles, such as disused meat-tins.

Occasionally offensive effluvia arise in connection with industries in which neither vegetable nor animal matters are used; as in the manufacture of sulphate or chloride of ammonia, and some other processes in which sulphuretted hydrogen is copiously evolved; and in the making of gas and the distillation of tar. The fumes from the manufacture of alkali and bleaching powder are acid and irritating, and produce very injurious effects on vegetation in the neighbourhood.

The distances to which nuisances extend vary greatly according to circumstances—as, for instance, the elevation at which the

effluvia are discharged into the air. Discharge from a high chimney often relieves the immediate vicinity of the works at the expense of those living at a greater distance. With a damp and comparatively stagnant atmosphere, effluvia have a much greater tendency to cling about a neighbourhood.

(2) The industrial processes in which offensive effluvia are produced are classified by Dr. Ballard as follows:—

1. The keeping of animals.
2. The slaughtering of animals.
3. Other branches of industry in which animal matters or substances of animal origin are chiefly dealt with.
4. Branches of industry in which vegetable matters are chiefly dealt with.
5. Branches of industry in which mineral matters are chiefly dealt with.
6. Branches of industry in which matters of mixed origin (animal, vegetable, and mineral) are dealt with.

(3) It is important to inquire to what extent offensive trade effluvia are injurious to the public health. It is impossible to bring statistics to bear on the inquiry, as other influences, apart from occupation, can scarcely be eliminated. The term "injurious to health" is capable of a double interpretation. It might mean either serious damage to health, or the mere production of bodily discomfort or other functional disturbance by the offensive effluvia, leading by its continuance to an appreciable impairment of vigour, though not to any actual disease.

It can scarcely be denied that in the latter sense offensive effluvia have a deleterious effect on health. Such symptoms as loss of appetite, nausea, headache, occasionally diarrhœa, and general malaise are produced by effluvia of various kinds, but agreeing in being all offensive. "A condition of *dis*-ease or *mal*-aise is produced."

There is little difficulty in proving bad effects on the workmen, though the invariable defence of manufacturers is an appeal to

the condition of health of their workmen. It is notorious that the workmen only remain such so long as they are healthy, and that as they become disabled they necessarily cease to rank among workmen. The decomposition of putrefying organic matters is unquestionably dangerous. The general doctrine of sanitation that filth is one of the chief factors in producing disease is certainly applicable to trade effluvia as well as to general sanitation. It has been alleged on behalf of such effluvia as chlorine sulphurous acid and tar vapours that they are useful disinfectants; but modern research has shewn that disinfectants, in order to be of practical use, must be in such a concentrated condition that the air containing them is irrespirable. Probably such septic diseases as erysipelas, and possibly also diphtheria, are favoured by organic trade effluvia.

(4) The means available to prevent or minimise the nuisances arising from trade effluvia vary with the character of the processes. The general principles on which treatment must be founded depend, as Dr. Ballard points out, on a recognition of the following kinds of effluvia :—

Effluvia dependent—1. On the accumulation of filth on or about business premises, or on its removal in an offensive condition.

2. On a generally filthy condition of the interior of buildings and premises and utensils generally.

3. On an improper mode of disposal of offensive refuse, liquid or otherwise.

4. On insufficient or careless arrangements in reception of offensive materials of the trade, or in removal of offensive products.

5. On an improper mode of storing offensive materials or products.

6. On the escape of offensive gases or vapours given off during some part of the trade processes.

It is evident that under the first two headings the proper remedy is cleanliness. Filth should be removed in impervious covered

vessels, at regular intervals. Structural arrangements should be made, which will facilitate cleansing operations. Solid refuse should, as far as possible, be separated from liquid refuse, as thus putrefaction is retarded.

Under the last head important remedies are applicable. In many cases a careful selection of the materials of manufacture will form an effective remedy. Thus much of the nuisance connected with soap or candle works arises from the putrid condition of the fat collected from butchers and marine store dealers, and might be obviated by more regular and more frequent collection of the materials of manufacture. The offensive vapours arising during processes of manufacture may be intercepted before reaching the external air, and so treated that they lose their obnoxious character. Various methods of interception are adopted, according to the processes involved. Occasionally it is necessary to have the air of the entire workshop drawn by means of artificial ventilation in a special direction; usually the interception of air from special chambers suffices. When thus collected, the offensive air may be dealt with by (1) passing it through water or some other liquid capable of absorbing the offensive materials; or (2) passing it through some powder with which it has chemical affinity; or (3) if its offensive materials are capable of condensation by cold, passing them through an appropriate condensing apparatus; or (4) if the evolved matters are organic in nature, conducting them through a fire. (5) Occasionally it is sufficient to discharge the offensive gases into the air from a high chimney; and this always produces a mitigation of nuisance, as compared with discharge at a low level.

It is usually found that the adoption of one or other of these methods is directly or indirectly profitable to the offender.

Nuisances from the Keeping of Animals.—The 47th section of the Public Health Act prohibits the *keeping of pigs* in towns so as to be a nuisance, and, as a general rule, it is possible to obtain

a magistrate's order entirely prohibiting the keeping of pigs in towns The excreta of the pig have a very offensive and penetrating odour, and however carefully kept, pigs in towns form an intolerable nuisance.

Not only is there nuisance from the accumulation of manure and dirtiness of the piggeries, but also from the storage and subsequent preparation of food. The boiling of hog-wash is often an even greater nuisance than the filth of the styes.

Cow-keeping and *horse-keeping* in towns are still allowed and, as compared with pig-keeping, form a very small nuisance. Mews if kept clean and well drained need not be offensive, though it is very objectionable on the ground of health for persons to sleep over stables. The removal of manure also constitutes a difficulty. Bye-laws should be in force insisting on frequent removal, and the manure should not be allowed to accumulate in deep wet pits, but on an iron cage-work, allowing free drainage and keeping the manure dry, and thus reducing ammoniacal decomposition to a minimum.

Cowsheds are generally very badly ventilated, as the cowkeeper finds that more milk is produced by the cows when the temperature of the shed is maintained at 65° or higher; and he is too parsimonious to provide artificial means of warmth. The grains which are used so largely for food are stored in a wet condition, and speedily give rise to nuisance. It is important that cowsheds and stables should be well paved and well drained, as soakage of urine and semi-fluid manure into the ground gives rise to foul emanations.

Cowsheds are regulated under the Dairies', Cowsheds', and Milkshops' Order of the Local Government Board. This order provides for and insists on the registration of cowkeepers, dairymen, and purveyors of milk, by the local authority. It also provides that no cowshed or dairy shall be occupied as such, unless provision is made to the satisfaction of the local authority, for the lighting and ventilation, including air-space, and the cleansing,

drainage, and water-supply of the same; and for the protection of the milk against infection or contamination. With the view of preventing contamination of milk, no person suffering from an infectious disorder, or having recently been in contact with a person so suffering, is allowed to milk cows or take any part in any stage of the business of a milk-seller.

Slaughtering of Animals.—Nuisance may arise in slaughter-houses from various causes:—(1) the uncleanly way in which animals are kept in the pound or lair before being killed; (2) the insanitary condition, bad paving, lack of lime-whiting of walls, etc., of the slaughter-house; (3) the accumulation of hides, blood, fat, offal, dung, or garbage on the premises; (4) the uncleanly condition of the blood-pits, or the receptacles for garbage; (5) the flowing of blood or offal into the drains communicating with the drains of other houses, or into the public sewer.

It may be hoped that ere long private slaughter-houses will be abolished, and it will be compulsory for all animals intended for human food to be slaughtered in public abattoirs under official supervision. When a large number of private slaughter-houses exist in different parts of a large town, it is impossible for the sanitary officials to properly supervise the slaughtering or to ensure that diseased meat shall not enter the market. The inspector may only have the opportunity of examining the flesh, the internal organs which more particularly show the presence of a diseased condition having been concealed. Such concealment and the consequent foisting of diseased meat upon the public, can only be efficiently prevented by the entire forbiddal of the slaughtering of any animal intended for food in a private slaughter-house.

Most local authorities have bye-laws regulating the slaughtering of animals. These provide for a cleanly condition of the lairs, and prevent keeping the animals longer in the lairs than is necessary for the purpose of preparation for slaughtering. They also insist on the provision of proper covered receptacles of iron or other non-

absorbent material for the reception of garbage, and other similar receptacles for blood; for cleansing of the floor, etc., after slaughtering; for lime-whiting of the walls four times a year; and for other matters of detail.

For *knackers' yards* similar regulations are applicable. The flesh should not be kept until it becomes putrid before being boiled, and the boiling of the flesh and fat should be so arranged as to avoid the escape of offensive vapours into the external air.

In *smoking bacon*, the singeing has formed a serious nuisance. *Fish-frying* in small shops is often a most troublesome nuisance. A hopper over the pan in which the frying is conducted has not been always successful in carrying the fumes up the chimney. The frying should preferably be done in a closed out-house, close to a chimney with a good up-draught.

The *fellmonger* prepares skins for the leather-dresser, the chief operations being taking off the wool, liming the skins, etc. The skins deprived of wool are called 'pelts.' The pelts are thrown into a pit containing milk of lime, and thence sent direct to the leather-dresser. Nuisance may arise from (1) the odour of the raw-skins; (2) the ammoniacal odour from the lime-painted skins hanging in the yard; (3) the emptying and cleansing of the 'poke' or tank in which the hides are washed; (4) the foul condition of the waste lime taken from the exhausted lime pits; (5) the odour from the dirty unpaved yards.

The *leather-dresser* only deals with "pelts," derived from sheep-skins; the tanner with bullocks' hides. The skins brought from the fellmonger to the leather-dresser are first deprived of lime, and then soaked in a solution of dog's dung, called "pure," until they become soft. In winter this "pure" solution is warmed for use. The odour is very abominable, both from the "pure" tub, and from the discharge of the exhausted "pure" liquid into the drain.

It is not necessary for our purpose to enter into details as to the various stages of *tanning*. At each stage nuisance may arise unless

great precautions are taken, as when the hides are soaked in lime and water, when the hair is being removed, when the loose inner skin of the hide is being removed, and especially when the hides are soaked in pits containing pigeons' or other dung. Nuisance may arise again during the passage of offensive hides through the street. Cleanliness is the great rule. If every process is carried on with due precautions, including frequent washing out of receptacles and the free use of disinfectants, little complaint need arise.

The manufacturers of *glue* and *size* boil out the gelatine from bits of hides and "fleshings" from leather dressers and tanners, from damaged "pelts," ox or calves' feet, horns, and other similar substances. The raw material is apt to be offensive in collection or while accumulating on the premises. The process of boiling causes offence by the effluvia from the steam. The residue remaining after the process is known as "scutch," and this, unless frequently removed, is a most serious source of nuisance.

Prussiate of Potass is manufactured by heating carbonate of potass with refuse animal matters. In order to avoid nuisance the pot in which the boiling is done should have a pipe to conduct away the steam, first running horizontally and then vertically down to the back part of the flue which underlies and heats the pot.

Fat-melting and *Dip-candle-making*, as usually carried on, give rise to nuisance. The fat which is melted down usually comes from butchers and marine-store dealers in a rancid or even putrid condition, and it may be stored on the premises for some time before it is boiled. The vapours from the melting-pan are very offensive. They should be carried by means of a pipe down until they discharge just under the boiler-fire. The residue from the fat-melting process (known as "greaves") requires frequent removal to avoid nuisance.

Bone-boiling, in order to extract the fat and gelatine, is most offensive, and most difficult to deal with. After boiling, the bones are apt to give off offensive smells. The vapours from the closed

boiler should be condensed as far as possible in a worm condenser, and the remainder passed through a furnace fire.

In the manufacture of *artificial manures* nuisance is apt to arise (1) from the reception and accumulation of the raw materials, as putrid fish, putrid blood, scutch (the residue from the manufacture of glue), recently boiled bones, etc. ; (2) from the preparation of the raw material for use. Thus the drying of condemned fish or meat on open kilns is very offensive ; similarly the drying of sewage sludge. (3) From the process of mixing the materials of manufacture, irritant and offensive vapours being evolved, as for instance in the manufacture of manure by crushing bones, and converting into superphosphate by the addition of sulphuric acid. (4) From the removal of the manure from the hot den, after it has been dried. When sulphuric acid is mixed with coprolites or other mineral phosphates, most irritant and offensive vapours are produced, which may be perceived in some cases at the distance of a mile.

Blood-boiling is now almost obsolete, having been replaced by albumen-making and clot-drying. Nuisance may arise from the blood collected from slaughter-houses being in a putrid state ; and from the effluvia evolved during the drying process. These processes are usually regulated by bye-laws.

Gut-scraping, *gut-spinning*, and the *preparation of sausage-skins* are very closely akin. In gut-scraping the putrid intestines are deprived of their interior soft parts by scraping with pieces of wood, and are then, after being cleansed, ready for sausage skins. In gut-spinning the prepared gut is twisted into a cord. The small intestines of hogs and sheep are used for this purpose. The stench from these establishments is indescribably horrible. Extreme cleanliness is desirable. Immersion of the guts in common salt or chloralum solution is useful ; so also the use of impervious vessels, early removal of all refuse material, etc.

Brick and ballast burning are a frequent source of complaint in the neighbourhood of towns. *Brick burning* is conducted either in

kilns or clamps. When bricks are burnt in closed kilns comparatively little nuisance arises; but when they are burnt in open clamps the effluvia are very irritating, partly owing to the fact that very commonly house refuse, containing vegetable and animal matters, is burnt with the bricks. Clamp burning should be absolutely prohibited in the neighbourhood of large towns.

In *Ballast burning* stiff clay is converted by the agency of heat into a brick-like material, which is of use in road-making. The clay is usually burnt in heaps, mixed with ashes and breeze from dust-bins. The process is offensive unless carried on with precautions similar to those for brick-burning.

APPENDIX TO CHAPTER V

PROBLEMS AS TO DIETARIES.

Moleschott gives the following as a standard diet:—4·587 ounces avoir. of albuminoid or proteid material, 2·964 ounces of fatty material, 14·250 ounces of carbohydrates, and 1·058 ounces of salts; making a total of 22·859 ounces of dry food. Inasmuch as ordinary food contains from 50 to 60 per cent. of water, the total solid food is 46 ounces. To this must be added from 50 to 80 ounces of water taken as such in beverages.

According to Parkes 1 oz. of water-free proteid contains 69 grains of nitrogen and 233 of carbon; 1 oz. of water-free fat contains 0 grains of nitrogen and 345·6 of carbon; 1 oz. of water-free carbohydrate contains 0 grains of nitrogen and 194·2 of carbon.

Moleschott's diet, therefore, contains 310·5 grains of nitrogen and 4852 grains of carbon.

From the table given at page 48, and from the following table of per-centage amount of food stuffs in different foods, dietaries can be easily calculated.

	IN 100 PARTS.				
	Water.	Albuminates or Proteids.	Fats.	Carbohydrates.	Salts.
Uncooked meat with little fat ...	74·4	20·5	3·5	—	1·6
Cooked meat – without loss	54	27·6	15·45	—	2·95
Salt beef	49·1	29·6	0·2	—	21·0
White fish	78·0	18·1	2·9	—	1·0
Bread, white wheaten	40·	8·	1·5	49·2	1·3
Wheat flour	15·	11·	2·	70·3	1·7
Rice	10	5	·8	83·2	0·5
Oatmeal	15	12·6	5·6	63·0	3·
Peas (dry)	15	22·	2·	53·	2·4
Potatoes	74	1·5	·1	23·4	1·
Butter	8	2·	88	—	variable
Eggs (including shell, for which deduct 10 per cent.	73·5	13·5	11·6	—	1
Cheese	36·8	33·5	24·3	—	5·4
Milk	87·0	4·	3·5	4·8	·7

How much bread and cooked meat would be required to provide sufficient carbon and nitrogen per diem for a man engaged in moderate work ?

The amount of nitrogen required may for the purpose of this example be taken as 300 grains, and the amount of carbon required as 4,800 grains.

Now bread contains 5·5 grains of N and 119 of C per ounce.

Cooked meat contains 19 grains of N and 117·7 of C per ounce. (Page 48).

Let b = number of ounces of bread required,

and m = ,, ,, meat ,,

Then $5{\cdot}5b + 19m = 300$

Also $119b + 117{\cdot}7m = 4800.$

By working out this double equation, it will be found that

$$m = 5{\cdot}7 \text{ ounces (of meat)}$$
$$\text{and } b = 34{\cdot}85 \text{ ounces (of bread).}$$

How much oatmeal, milk, and butter, of the following percentage composition, would be required to give a sufficient quantity of albuminoids, fats, and carbohydrates to an adult male ?

For the purposes of this and the following example, the following figures may, for the sake of convenient calculation, be taken as representing the percentage amount of each of these chief food principles contained in the foods named.

	Albuminoids.	Fats.	Carbohydrates.
Oatmeal	12	6	60
Milk	4	3	5
Butter	2	88	—

Let o = number of ounces of oatmeal required.
m = ,, ,, milk ,,
b = ,, ,, butter ,,

Then $$\frac{12o + 4m + 2b}{100} = 4{\cdot}5 \text{ ozs. of albuminoid}$$

$$\frac{6o + 3m + 88b}{100} = 3 \text{ ozs. of fat}$$

$$\frac{60o + 5m}{100} = 14{\cdot}25 \text{ ozs. of carbohydrate,}$$

according to Moleschott's diet.

When these equations are worked out by substitution and transference

$o = 19{\cdot}2$ ounces.
$m = 55{\cdot}4$,,
$b = 0{\cdot}24$,,

How much meat, bread, and butter of the following per-centage composition will be required to give a man a sufficient amount of albuminoids, fats, and carbohydrates?

	Albuminoids.	Fats.	Carbo-hydrates.
Meat ...	25	15	0
Bread ...	8	1·5	50
Butter ...	2	88·	0

Let m = number of ounces of meat required.
b = ,, ,, bread ,,
B = ,, ,, butter ,,

Then $$\frac{12m + 8b + 2B}{100} = 4{\cdot}5 \text{ ozs. of albuminoid}$$

$$\frac{15m + 1{\cdot}5b + 88B}{100} = 3 \text{ ozs. of fat}$$

$$\frac{50b}{100} = 14{\cdot}25 \text{ ozs. carbohydrates.}$$

When these equations are worked out

$m = 6{\cdot}28$ ounces.
$b = 28{\cdot}5$,,
$B = 1{\cdot}15$,,

What are the proportions of the respective alimentary constituents contained in (a) milk, (b) potatoes, (c) rice, (d) butter, (e) bread? How much milk would be required to supplement the daily dietary of a man eating 3 lbs. of potatoes? (*D.P.H. Exam. Camb. Univ., 1891.*)

We assume that 300 grains of nitrogen and 4,800 grains of carbon are required, and find from the table on p. 48 that every ounce of potato contains 1 grain of nitrogen and 49 of carbon, and every ounce of milk 2·75 grains of nitrogen and 30·8 of carbon.

It follows that 3 lbs. = 48 ozs. of potatoes contain 48 grains of nitrogen and $48 \times 49 = 2{,}352$ grains of carbon.

Therefore $300 - 48 = 252$ grains of nitrogen,

and $4{,}800 - 2{,}352 = 2{,}448$ grains of carbon, require to be supplied from the milk.

One ounce of milk supplies 2·75 grains of nitrogen; therefore 252 grains of nitrogen are supplied by

$$\frac{252}{2{\cdot}75} = 91{\cdot}6 \text{ ozs. of milk.}$$

One ounce of milk supplies 30·8 grains of carbon; therefore 2,448 grains of carbon are supplied by

$$\frac{2{,}448}{30{\cdot}8} = 79{\cdot}5 \text{ ozs. of milk.}$$

It is evident that in order to obtain sufficient nitrogen, some excess of carbon would be taken, viz., that contained in the difference between 91·6 and 79·5 ozs. of milk (20 ozs. is equal to an imperial pint).

Energy Obtainable from Food.—Drs. Frankland and Playfair, assuming that the analogy of Joule's law held good as regards the energy obtainable from food, calculated the amount of potential energy contained in various food stuffs. Joule discovered by exact experiment that the mechanical power obtained from a given amount of fuel is directly proportional to the amount of fuel used, being in fact due to the oxidation of this fuel, the heat produced being transformed into mechanical power. Calculating on the same basis, Frankland estimated that—

1 oz. dry albumin	yields	174	foot-tons of	potential energy
,, fat	,,	378	,,	,,
,, starch	,,	135	,,	,,
,, cane sugar	,,	129	,,	,,
,, glucose or lactose	,,	122	,,	,,

Playfair calculated that 1 oz. of dry albumin would by oxidation produce enough heat to raise 125 kilogrammes of water 1°C, or to lift 173 tons one foot high, which corresponds closely to Frankland's result.

It must be remembered, however, that metabolism within the body is by no means identical with oxidation outside it; and that albumin and other allied bodies do not become completely oxidised within the body, but leave it in the form of urea, which is a comparatively complex body. Further, the ease with which a body is digested and assimilated in the body, by no means corresponds with the ease with which the same body would undergo oxidation.

The above estimates of potential energy must therefore be taken as only theoretically correct. It would appear from these estimates that fat is nearly three times as valuable as the same weight of starch; but in all probability it is not more than one and a half times as valuable. Inasmuch, however, as examination questions are still given on the basis of the theoretical data supplied by Frankland and Playfair, I append the following example:—

A man does work equal to 176·8 foot-tons in a day. Supposing that he eats only bread, how much will he require to develop the amount of force required?

Now bread contains 8 per cent. proteid, 1·5 per cent. fat, and 49·2 per cent. carbohydrate.

Therefore from 100 ounces of bread the amount of potential energy obtainable is as follows:—

$8 \times 174 = 1{,}392$ foot-tons
$1{\cdot}5 \times 378 = 567$,,
$49{\cdot}2 \times 135 = 6{,}642$,,
Total energy $= 8{,}601$,, obtained from 100 ozs. bread.

Let b = number of ounces of bread required to develop 176·8 foot-tons of energy.

Then $8{,}601 : 100 :: 176{\cdot}8 : b$.

Therefore $b = \underline{2{\cdot}05 \text{ ounces}}$.

How much work in foot tons can be expected from a diet consisting of cooked beef 10 ozs., bread 24 ozs., butter 1 oz., and potatoes 20 ozs.? (Honours Sc. Exam., 1887.)

The following table gives the approximate percentage composition of the articles named.

	ALBUMINOIDS.	FATS.	CARBOHYDRATES.
Cooked Beef	25	15	—
Bread	8	1·5	50
Butter	2	88·	—
Potatoes	1·5	·1	23

From this can be calculated the number of ounces of each of these three food-principles in the foods given. It is as follows :—

	ALBUMINOIDS.	FATS.	CARBOHYDRATES.
Cooked Beef	2·5	1·5	—
Bread	1·9	·36	12
Butter	·2	·88	—
Potatoes	·3	·2	4·6
	4·9	2·94	16·6

4·9 ozs. of albuminoids yield 174 × 4·9 = 852·6 = work in foot tons.
2·94 „ fats „ 378 × 2·94 = 1111·32 = „ „
16·6 „ carbohydrates „ 135 × 16·6 = 224·10 = „ „

The total amount of potential energy developed from the given amount of food therefore = 2188·02 foot tons.

APPENDIX TO CHAPTER XIX.

PROBLEMS AS TO VENTILATION.

The amount of carbonic acid present in a given atmosphere has been usually taken as the test of its relative salubrity. This is only true in so far as it is found that the amount of carbonic acid decreases and increases in proportion to the amount of organic matter in air. Pure carbonic acid, in the proportions in which we find it in the worst ventilated rooms, is not in itself a dangerous impurity, but it is the bad company in which it is usually found that renders it a fairly trustworthy, as well as simple, test of the

amount of impurity in air. There are certain fallacies in this test. In a soda water manufactory, for instance, there would be a comparatively harmless excess of carbonic acid. In dirty rooms, and in hospitals and other institutions where rooms are not vacated for a considerable period, the amount of organic matter present is often in excess of what would have been anticipated, judging by an estimation of the carbonic acid present. This is strikingly shown by some valuable researches at Dundee, which are summarised in the following table. If we take the average amount (in excess of outside air) of carbonic acid, organic matter, and micro-organisms respectively in houses of four or more rooms as unity, then in one or two-roomed houses or tenements we have as follows:—

	HOUSES OF FOUR ROOMS AND UPWARDS.	TWO-ROOMED HOUSES.	ONE ROOMED HOUSES.
Carbonic Acid	1	1·5	2·0
Organic Matter	1	1·6	4·4
Micro-organisms	1	5·1	6·7

It is evident that in these cases the carbonic acid did not increase in the same proportion as the organic matters and micro-organisms, and that it alone does not form a sufficient test of the impurity of any given atmosphere.

The amount of carbonic acid is, however, taken as a rough test of the condition of the air in a room, and most mathematical problems connected with ventilation are founded on this assumption, and the following examples from various examination papers are based on this supposition. (*See page 168.*)

It is often necessary to ascertain the number of cubic feet of air which must be supplied per hour in order to keep down the carbonic acid in a given atmosphere below the permissible limit, which is usually taken as ·06 per cent.

This limit we may add, although theoretically correct, is difficult to enforce in practice.

The following formula enables problems relating to ventilation to be solved. Let p = the amount of poison (carbonic acid) in every cubic foot of fresh air, viz. ·0004 cubic foot. Let A = the number of cubic feet of fresh air delivered or available, P = the amount of carbonic acid exhaled, and x = the amount of carbonic acid per cubic foot in the room at the end of a given time. Then

$$x = p + \frac{P}{A}, \text{ whence } A = \frac{P}{x + p}$$

If the carbonic acid in the air of a room is ·75 per 1000 volumes (that in the outer air being ·4 per 1000 volumes), and there are five persons in the room, how much air is entering the room per hour?

(*Science Department, Honours Examination, 1883.*)

Here x = ·00075
p = ·0004
P = ·6 (*i.e.* number of cubic feet of carbonic acid expired by each person per hour).

Now $x = p + \dfrac{P}{A}$

$\cdot 00075 = \cdot 0004 + \dfrac{\cdot 6}{A}$

Therefore A = about 1700

Thus 1700 cubic feet are required for each individual to keep the air within the given limit, and five times this amount will be required for five persons = 8,500 cubic feet.

A room has been occupied for one hour, at the end of which the total carbonic acid present was found to be 1·1 per 1,000 parts. The carbonic acid in the open air amounting to ·0004 per cubic foot, find the quantity of air supplied per hour.

Here x = ·0011
p = ·0004 and P = ·6

Hence $\cdot 0011 = \cdot 0004 + \dfrac{\cdot 6}{A}$

Therefore A = 857 cubic feet.

If six persons are in a room containing 3,000 cubic feet, and there is a supply of 2,000 cubic feet of air per head per hour; how much carbonic acid is there in the air of the room at the end of 4 hours?

(*Science Department*, 1886.)

Here $p = \cdot 0004$

$$P = \cdot 6 \times 6 \times 4 = 14\cdot 4$$

$$A = (2000 \times 6 \times 4) + 3000 = 51000$$

$$x = \cdot 0004 + \frac{14\cdot 4}{51000} = \cdot 000682 = \underline{6\cdot 82 \text{ parts } CO_2} \text{ in } 10,000 \text{ of air.}$$

The air of a room occupied by 6 persons and containing 5,000 cubic feet of space, yields 7·5 parts of CO_2 per 10,000 parts of air. How much air is being supplied per hour? (*Cambridge University Examination*, 1884.)

$$A = \frac{P}{x - p} = \frac{\cdot 6 \times 6}{\cdot 00075 - \cdot 0004} = \underline{10,280} \text{ cubic feet.}$$

In the same room what would be the condition of the air at the end of 4 hours?

$$x = \cdot 0004 + \frac{\cdot 6 \times 6 \times 4}{(10280 \times 4) + 5000}$$

$$= \cdot 0004 + \frac{14\cdot 4}{46120} = \cdot 000712 = \underline{7\cdot 12 \text{ of } CO_2} \text{ in } 10,000 \text{ of air.}$$

Given two sleeping rooms, Y 10 ft. by 15 ft. and 10 ft. high, Z 15 ft. by 20 ft. and 12 ft. high, with three adults in each; how much fresh air would you supply in each? What would be the condition of the air of each of the rooms after ¼, ½, 1, and 2 hours respectively? (London University Exam., 1883.)

Amount of fresh air to be supplied in Y

$$A = \frac{P}{x - p} = \frac{\cdot 6 \times 3}{\cdot 0006 - \cdot 0004} = \underline{9000} \text{ cubic feet per hour.}$$

Condition of air in Y after ¼ hour

Here $p = \cdot 0004$

$$P = \frac{\cdot 6 \times 3}{4} = \cdot 45$$

$$A = \frac{9000}{4} + 1500 = 3750$$

$$x = \cdot 0004 + \frac{\cdot 45}{3750} = \underline{\cdot 00052.}$$

At the end of 2 hours

$$x = \cdot 0004 + \frac{3\cdot 6}{18000 + 1500} = \underline{\cdot 000584.}$$

And similarly for Z.

Suppose two rooms, one 10 feet cube, the other 50 feet by 20 feet and 15 feet high, have continuously admitted into each of them a volume of fresh air containing ·04 parts carbonic acid per 100 parts, amounting to 2,000 cubic feet per hour, so as to replace to that extent the air of the room; suppose also that

an average adult be placed in each room: show by detailed calculation what would be the condition of impurity of air in each room, as measured by carbonic acid, at the end of 4 hours and 12 hours respectively. (London University Examination, 1877.)

In the case of the first room

$$P = \cdot 6 \times 4 = 2\cdot 4$$
$$A = (2000 \times 4) + 1000 = 9000$$
$$p = \cdot 0004.$$
$$x = \cdot 0004 + \frac{2\cdot 4}{9000} = \underline{\cdot 000667.}$$

The amount of impurity at the end of 12 hours, and in the second room may be similarly ascertained.

Ventilation.—The temperature of a given atmosphere is a most important factor in determining the ease with which it is replenished from the external air. Speaking generally, the greater the difference between the temperature of two masses of air the more rapidly an interchange occurs.

Air has weight. A column of it one inch square and extending to the uppermost limit of the atmosphere weighs about 14·6 lbs., and exerts this pressure on all substances at the surface of the earth. This pressure is exerted uniformly in all directions; but for this fact our chests would be crushed in by the external pressure on them, which amounts to over four tons. If the atmospheric pressure is diminished at any point, it is evident that the surrounding air will tend to press in this direction. Now, when air is heated it expands, and consequently the heavier fresh air flows in from all sides and pushes the lighter air upwards.

The expansion of air for every increase of 1° Cent. is ·003665 ($\frac{1}{273}$), for every increase of 1° Fahr. is ·00203 ($\frac{1}{492}$). Thus if the air in a room is 20° F. warmer than that outside, it will be expanded to $\frac{1}{25}$ additional bulk.

Thus if M = volume of a given air at 32°, with the barometer at 30 inches, and

M_1 = volume at temperature $t°$ above 32°, while a = coefficient of expansion for each degree of elevation of

temperature, then the dilatation effected by heat will be expressed by the formula—

$$M_1 = M(1 + at).$$

When the temperature is decreasing,

$$M_1 = M(1 - at).$$

If the air in a chimney flue is cooler than the air of the room with which it communicates, it will flow down into the room. It is the object of an economical fireplace to cause the chimney to act as an outlet for the products of combustion and for the impurities of the air of the room with the smallest possible waste of heat. Short of producing a down draught of cold air and smoke, the smaller the difference between the temperature of the air of a room and of the air escaping near the top of the chimney, the greater the economy of the fire.

The **movement of air in flues and other outlets** is governed by general laws, like those governing the general movements of fluids, but allowances require to be made for friction in the channels of entrance and outlet.

The theoretical velocity, when friction is not taken into account, may be calculated by a formula based on what is known as the *law of Montgolfier*, or the law of spouting fluids. According to this law, fluids pass through an opening in a partition with the same velocity as a body would attain in falling through a height equal to the difference in depth of the fluid on the two sides of the partition, *i.e.*, to the difference of pressure on the two sides. Thus, if AB equals the height of a column of air at say 50° F., and AC is the height of the same quantity of air heated to 60°, then the velocity at which the warmer air ascends will be that which a body would acquire in falling from C to B.

Now the velocity in feet per second of falling bodies is about eight times the square root of the height from which they have fallen; and the formula for determining this is—

$$v = c\sqrt{2gh} = 8{\cdot}2c\sqrt{h}.$$

In this formula v = required velocity in feet per second:
g = 32·17 feet per second:
h = distance fallen through by the body:
c = a constant determined by experiment, and expressing the proportion of the actual to the theoretical velocity.

Adapting this formula to the special circumstances under which Montgolfier's formula holds, we find that the force which drives the warm air up the flue is the force of gravity, *i.e.*, of the excess of the weight of a column of cold air over the weight of a column of warm air of exactly the same size (represented by BC in the above diagram). The difference of the two weights or pressures is found by multiplying the distance from the point of escape of heated air out of the room (fireplace or elsewhere) to the point of escape into the outer air (top of chimney or other point of exit), by the difference in temperature inside and outside, and again multiplying this product by $\frac{1}{492}$ for degrees of Fahrenheit temperature, or $\frac{1}{273}$ for degrees Centigrade.

Thus omitting c for the present, we have

$$v = \sqrt{\frac{2\,gh\,(t - t^1)}{492}} = 8{\cdot}2\sqrt{\frac{h\,(t - t^1)}{492}}$$

Where t = temperature in the chimney,
t^1 = temperature of the external air, and
h = height of chimney.

The chief means of ventilating a given room is by its open fireplace. The temperature in the chimney is 100° F., that of the external air 40°, and the height of the chimney 50 feet; what is the velocity with which air is leaving the room?

$$v = 8{\cdot}2\sqrt{\frac{(100 - 40) \times 50}{492}}$$
$$= \underline{20.}$$

This gives the theoretical velocity, but the real velocity will differ from the theoretical by an amount varying from 20 to 50 per cent.

It will be evident from what has been said, that the movements of the air in a confined space are dependent upon (1), the difference between the internal and external temperatures; (2), the area and

friction at the apertures through which air enters and leaves the room; and (3), the height of the column of ascending warm air. The higher the chimney (assuming it to contain warmed air), the greater the draught and the more efficient the ventilation of the room communicating with it.

Allowance for Friction.—Practically the friction varies greatly according to the size, form, and material of outlet for air. A rough or sooty or angular chimney greatly impedes the outgoing current of air.

It is usual to reduce the theoretical velocity by 20 to 50 per cent. Apart from the friction which is governed by roughness and length of channels, that due to bends in the channel may be calculated by the formula $\frac{1}{1 + \sin^2 \theta}$, θ being the angle at any bend in the channel.

(It may be convenient to note that

$$\sin^2 90^\circ = 1, \sin^2 60^\circ = \tfrac{3}{4}$$
$$\sin^2 45^\circ = \tfrac{1}{2}, \sin^2 30^\circ = \tfrac{1}{4}.)$$

Thus every right angle in a bent shaft reduces the velocity in it by one-half.

The loss by friction in two similar tubes of equal sectional area varies (1) directly with the square of the velocity of the air currents; and (2) directly with the length of the outlet channel. In two similar tubes of unequal size the loss by friction is (3) inversely as the diameter of the cross-section in each.

When two tubes are of different shapes, the loss by friction is inversely as the square roots of the sectional areas.

Owing to the variable value of the coefficient of friction (called c in the first formula given), it is usually preferable to measure the actual rate of progress of air through a given flue by means of an anemometer (wind measure). Then having given the velocity of the current of air and the area of the cross section of the flue, the volume of air discharged in a given time is represented by the product of these two and the time which has elapsed.

$$\text{Thus, } q = a \times v$$

Where q = quantity of air discharged in a given time, a = area of cross section of flue, v = velocity of current.

By means of this formula, the area of chimney required to discharge a given volume of air at a given average velocity can be ascertained. Thus,

$$a = \frac{q}{v}$$

The application of the preceding principles and formulæ will be rendered clearer by the following examples.

How much inlet and outlet area per head will be required to give 10 persons in a room of 5000 cubic feet capacity, 2000 cubic feet of air per head per hour, supposing that the outside temperature is 40°, while the internal temperature is 60°, and the height of the heated column of air 20 feet?

First ascertain the velocity of entrance and exit of air.

$$v = 8{\cdot}2\sqrt{\frac{h\,(t - t^1)}{492}}$$

$$= 8{\cdot}2\sqrt{\frac{20\,(60 - 40)}{492}} = 8{\cdot}2 \times {\cdot}902$$

$$= 7{\cdot}3964 = \text{velocity in feet per second.}$$

If we allow one fourth for friction then there remains a velocity of 5·5473 feet per second.

5·5473 feet per second = 19700·8 feet per hour.

$$\text{Now, } a = \frac{q.}{v.}$$

$$= \frac{2000}{19700{\cdot}8} = {\cdot}1015 \text{ square feet.}$$

$$= \underline{14{\cdot}6 \text{ square inches.}}$$

Thus the size of the outlet required per head is 14·6 square inches. The size of the room and the number occupying it do not enter into the question, except for a short time at the beginning; during which it might be assumed that, as there are 5,000 cubic feet of air in the room, no inlets or exits will be required, until this is brought down to the allowable limit of impurity (6 parts of carbonic acid in 10,000 of air).

The amount of inlet required will also be 14·6 square inches per head. Theoretically it ought to be slightly less than that required for outlet, as the out-going air is more expanded than that entering the room; but practically no allowance need be made for this fact.

The total amount of inlet and outlet required per head = 29·2 square inches.

If the mean temperature of a room is 61°, the external temperature 45°, while the heated column of air is 50 feet, and the required delivery of air 2000 cubic feet per hour, find the size of inlet and outlet.

$$v = 8{\cdot}2\sqrt{\frac{h\,(t - t^1)}{492}}$$

$$= 8{\cdot}2\sqrt{\frac{50\,(61 - 45)}{492}}$$

$$= \underline{10{\cdot}55 \text{ feet per second.}}$$

$$= \underline{37980 \text{ feet per hour.}}$$

If we make no allowance for friction, then

$$a = \frac{q.}{v.}$$

$$= \frac{2000}{37980} \text{ square feet.}$$

$$= \frac{2000 \times 144}{37980} = 7{\cdot}58 \text{ square inches.}$$

This gives the required size of outlet. The size of inlet and outlet together = <u>15·16 square inches.</u>

If 3000 cubic feet of air are supplied in one hour through an aperture of 12 square inches to a room containing 1000 cubic feet of space, at what rate does the air enter the room?

$$12 \text{ square inches} = \tfrac{1}{12} \text{ square foot.}$$

$$a = \frac{q.}{v.}$$

$$\frac{1}{12} = \frac{3000}{v}$$

$$\text{Therefore } v = 36000 \text{ feet per hour.}$$

$$= \underline{10 \text{ feet per second.}}$$

If a room is supplied with 3000 cubic feet of air per hour, through a single opening, what must be its area, if the rate of movement of the air is 5 feet per second?

$$5 \text{ feet per second} = 18000 \text{ feet per hour.}$$

$$a = \tfrac{3000}{18000} = \tfrac{1}{6} \text{ square foot.}$$

$$= \underline{24 \text{ square inches.}}$$

The difficulties connected with the estimation of amount of friction greatly detract from the practical value of the formulæ just given. It has been found necessary to make actual measurements of the velocity of air-currents by means of an anemometer.

The results given by anemometers are not always trustworthy, but by comparing the results given by them with the results obtained by the use of Montgolfier's formula an approximate result can be obtained.

The ordinary anemometer consists of four tiny vanes fixed to a spindle, so that revolutions are caused by the current of air the velocity of which is to be measured. The revolutions are counted by a mechanical arrangement. The value of the revolutions of the vanes has to be first determined by direct experiment; a known bulk of air being forced through a channel of known size at a uniform rate, and the instrument graduated accordingly. In Fletcher's anemometer a modification of the manometer or pressure-gauge has been used for the same purpose.

Inlets and Outlets.—If it be assumed that a man measures 6 feet by $1\frac{1}{2}$ feet, he presents a superficial area of 9 square feet. If we multiply this area by the average velocity of the air in the open (*i.e.*, 10 feet per second or about 7 miles per hour), we find that in an hour 324,000 cubic feet of air flow over one person in the open air. It is evident, therefore, that if 3,000 cubic feet be introduced each hour into a room for each person in it, the allowance is only about $\frac{1}{100}$ of that enjoyed in the open air.

Having given the average velocity of the wind, the size of a room, and the number of persons occupying it, the size of inlet opening required can easily be calculated.

Find the size of inlet for air in a room occupied by one person, the air moving at the average velocity of 5 *feet per second, assuming that* 3,000 *cubic feet of air is to be supplied per hour.*

Let x = size of inlet,
Then $x \times 60 \times 60 \times 5 = 3{,}000$,
Therefore $x = \frac{3000}{18000} = \frac{1}{6}$ square foot.
$= \underline{24 \text{ square inches.}}$

Given that the air moves at a velocity of 10 *feet per second, and that the area of the inlet aperture into a room is* 12 *square inches, find how much air enters the room in an hour.*

Let y = amount of air,
Then $10 \times 60 \times 60 \times \frac{12}{144} = y$,
Therefore $y = \underline{3{,}000 \text{ cubic feet of air.}}$

Calculations as to supply of air in a room founded on the *average* velocity of air-currents, are, however, much less trustworthy than when the velocity is determined, as previously explained, by means of Montgolfier's formula, or, better still, by an anemometer.

Practically it is found that a change of the air in an occupied room three or four times in an hour is all that can be borne under ordinary circumstances in this country. The only exception to this statement is when the incoming air is warmed, thus preventing the perception of draughts.

The Commissioners on Improving the Sanitary Condition of Barracks and Hospitals, in their report (1861) recommended for *inlets*, one square inch for every 60 cubic feet in the contents of the room; or one square inch for every 120 cubic feet in the contents, if warm air is admitted round the fire-grate. For *outlet* shafts on lower floor one square inch to every 60 cubic feet, slightly increasing for the higher stories.

Amount of Air-space required.—We may take 3,000 cubic feet of air as the average amount of air required hourly by each individual, and inasmuch as the air of a room cannot be changed oftener than three times in an hour without producing an unpleasant draught, it follows that at least 1,000 cubic feet of space must be allowed per person.

This may be compared with the amount actually supplied under various circumstances.

In the British Army for each soldier,

In permanent barracks, ...	600	cubic ft.
In wooden huts.	400	,,
In hospital wards at home	1,200	,,
In hospital wards in the tropics ...	1,500	,,
In wooden hospitals at home	600	,,
In general hospitals ...	1,000-1,500	,,
In fever hospitals	2,000-3,000	,,
In workhouse hospitals ...	850-1,200	,,

In common lodging houses	300	cubic ft.
Do., if occupied night and day ...	350	,,
In workhouses	300	,,
In Schools—		
London School Board requires per scholar	130	,,
English Educational Department per scholar (minimum)...	80	,,

Floor-space has an important bearing on ventilation. In calculating the available cubic space of a room, the height over twelve feet should be disregarded. Thus, if 500 cubic feet is allowed for each individual, the floor-space should be 42 square feet. In barracks, soldiers are allowed 50 square feet of floor-space.

For schools, the Educational Department require at least 8 square feet of floor-space for each scholar. If we assume that 1,500 cubic feet of air are required hourly for each scholar, then an allowance of 80 cubic feet of air-space involves that the air must be replenished 19 times each hour. So frequent an exchange of air is impossible, unless warmed air is introduced, or mechanical means of ventilation are employed, and it follows that the air in most schools is in a very vitiated condition.

In the Government regulations for workhouses it is stated that there must not be more than two rows of beds, and that the height of rooms above 12 feet must not be reckoned. This gives a minimum floor-space of 25 square feet per occupant.

In hospitals, the question of floor-space is extremely important, as it regulates the distance between the sick inmates and the convenience of nursing. Assuming each bed to be 3 feet wide and $6\frac{1}{2}$ feet long, the distance between any two beds should be at least 5 feet. This makes the wall-space for each bed 8 feet long. If the width of the ward is 25 feet, then there is a passage 11 feet wide between the two rows of beds for the whole length of the ward. The superficial space available for each bed is $\frac{25}{2} \times 8 =$ 100 square feet. If the height of the ward be reckoned as 12 feet, then the available cubic space is 1440 cubic feet.

Usually a wall-space of $7\frac{1}{2}$ feet is allowed for each bed, which, with a ward 25 feet wide, would allow about 94 square feet of space for each bed. At St. Thomas's Hospital the allowance is 112 square feet. In Fever Hospitals the floor-space should be 150 to 300 square feet. *(See also page 179.)*

Means of ascertaining Cubic Space.—Circumference of a circle = Diameter (D) × 3·1416.

Area of circle = $D^2 \times \cdot 7854$.

Area of square = square of one of its sides.

Area of rectangle = product of two adjacent sides.

Area of triangle = base × $\frac{1}{2}$ height, or height × $\frac{1}{2}$ base.

Area of ellipse = product of the two diameters × ·7854.

Circumference of ellipse = half the sum of the two diameters × 3·1416.

Area of any polygon found by dividing into triangles, and taking the sum of their areas.

Cubic capacity of a cube found by multiplying the three dimensions together.

Cubic capacity of a cylinder = area of base × height.

Cubic capacity of a cone or pyramid = area of base × $\frac{1}{3}$ height.

Cubic capacity of a dome = area of base (circle) × $\frac{2}{3}$ height.

Cubic capacity of a sphere = $D^3 \times \cdot 5236$.

Area of segment of a circle found by adding to $\frac{2}{3}$ of product of chord and height, the cube of the height divided by twice the chord.

$$(Ch \times H \times \tfrac{2}{3}) + \frac{H^3}{2\,Ch}.$$

Give the dimensions of a circular ward for 12 patients, each to have 1,750 cubic feet of available air-space.

Capacity of ward = 1,750 × 12 = 21,000 cubic feet.

If we allow 120 square feet floor-space for each patient, then the total floor-space will be 1,440 square feet. Consequently the height of the ward $= \frac{21000}{1440} = 14{\cdot}75$ feet.

$$\text{Area of circle} = D^2 \times \cdot 7854.$$

$$\frac{1440}{\cdot 7854} = D^2$$

$$\text{Therefore } D = \underline{43{\cdot}2 \text{ feet.}}$$

$$\text{Circumference of circle} = D \times 3{\cdot}1416$$
$$= 43{\cdot}2 \times 3{\cdot}1416$$
$$= \underline{135{\cdot}7 \text{ feet.}}$$

The dimensions of the circular ward required are therefore a height of 14·75 feet, diameter of 43·2 feet and circumference of 135·7 feet.

Find the cubic capacity of a circular hospital ward 28 feet in diameter, 10 feet high, and with a dome-shaped roof 5 feet high.

Area of floor-space $= D^2 \times {\cdot}7854$

$= 614{\cdot}8$ square feet.

Cubic capacity of the cylinder below the dome is

$614{\cdot}8 \times 10 = 6148$ cubic feet.

Cubic capacity of the dome $= 614{\cdot}8 \times \frac{2}{3} \times 5 = 2049{\cdot}3$ cubic feet.

Total cubic capacity of the ward $=$ $\underline{8197{\cdot}3 \text{ cubic feet.}}$

In practical measurements of rooms deductions must be made from the cubic space for the furniture contained in it and for its inmates. About 10 cubic feet ought to be allowed for each bed and bedding, and $2\frac{1}{2}$ to 4 cubic feet for each individual. Projecting surfaces must be allowed for by subtraction, and recesses by addition.

A circular ward with a diameter of 36 feet has a dome-shaped roof, the height of whose centre is 18 feet. The height to the dome is 12 feet. Find the floor-space and total cubic contents. How many patients ought the ward to accommodate?

Area of floor-space $= (36)^2 \times {\cdot}7854$

$= 1017{\cdot}8784$ square feet.

Cubic capacity of cylinder below dome

$= 1017{\cdot}87 \times 12 = 12214{\cdot}5$ cubic feet.

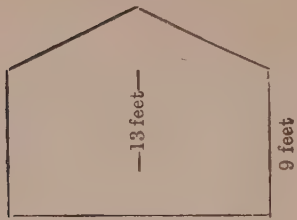
Cubic capacity of dome $= 1017{\cdot}87 \times \frac{2}{3} \times 6 = 4071{\cdot}48$ cubic feet.

Total cubic capacity of the ward $=$ $\underline{16285{\cdot}98 \text{ cubic feet.}}$

Assuming that 1,500 cubic feet are required for each patient, then the ward is large enough for *10 patients.* It is well to test this conclusion by calculating whether sufficient floor space has been allowed for each patient. The floor space has been found to be about 1,018 square feet, which would give 100 feet for each of 10 patients and more than the minimum standard previously stated.

What number of people should be allowed to sleep in a dormitory 40 feet long, of which the accompanying sketch is a section?

(Sanitary Institute, Examination for Inspectors of Nuisances.)



The cubic capacity of the quadrilateral space below the roof = 16 × 9 × 40 = 5,760 cubic feet.

Area of floor = Area of base of roof = 40 × 16 = 640 square feet.

Cubic capacity of roof = 640 × $\frac{1}{3}$ (13 − 9)
= 853·3 cubic feet.

Total cubic capacity of dormitory = 6613·3 cubic feet.

If we take the low Standard of Common Lodging Houses and allow 350 cubic feet of space for each inmate, then *18 persons* may be allowed to sleep in the dormitory.

How is cubic space measured? What is its relation to ventilation? How much space would a man occupy supposing him to weigh 175 lbs.? How much is usually allowed for a man with his clothes, bed and bedding?
(Cambridge University Examination, 1887.)

Cubic space is measured differently according to the shape of the building (*Vide antea*).

We have previously shown that the cubic space of a room is theoretically of less importance than the capacity for frequent interchanges of air. Even the largest room can only supply air for a limited period, unless fresh air is admitted. Practically, however, a large room is very advantageous, as it enables the interchanges of air to occur without serious inconvenience from draughts.

The space occupied by a man is stated by Parkes to be from $2\frac{1}{2}$ to 4 cubic feet (say 3 for the average). He gives the following rule :—The weight of a man in stones divided by 4 gives the cubic feet he occupies. Thus a man weighing 12 stones occupies 3 cubic feet.

About 10 additional cubic feet must be allowed for clothing, bedding, and bed for each person.

A man weighing 175 lbs. would, according to the preceding rule, occupy $3\frac{1}{8}$ cubic feet of space.

What size of inlet and outlet aperture should be allowed per head? How

large should each individual inlet be made? If an inlet aperture 100 square inches in area is divided into four, with apertures of 25 square inches each, what is the loss by friction?

A size of 24 square inches per head for inlet and the same for outlet meets common conditions.

It is desirable to make each individual inlet not larger than 48 to 60 square inches in area, *i.e.*, large enough for two or three men; and each outlet not larger than one square foot, or enough for six men (Parkes). This ensures more uniform diffusion of the air throughout a room. On the other hand the loss by friction is greatly increased by having a number of small openings instead of one large opening. This loss is inversely to the square roots of the respective areas. Thus the square root of 100 is 10, the sum of the square roots of the four apertures of 25 square inches each is 20. The loss by friction is double in the second case what it was in the undivided opening. It is evident, therefore, that in order to get as much air through the four openings as through the original large opening, each must be equal in size to half the original opening.

Why is ventilation more difficult in upper rooms of large houses and in singled-storied houses than in the lower stories of large houses?

Cold external air being heavier than the internal warm air presses downwards to the lowest point, and pushes up the warmer air. If there were a vacuum in the room, air would rush into it with a velocity which as seen before is represented by the formula

$$v = \sqrt{2gs}$$

Where $g = 32$, $s =$ height of column of air, which we may take as roughly 5 miles.

From this formula we obtain $v = 1306$ feet per second.

It is evident that in such a case the velocity of entry of air into a vacuum on the ground floor would be greater than into a vacuum on any of the higher stories, owing to the greater velocity acquired through the increased action of gravity.

And the same increased facility of entry of air into lower rooms must hold good under ordinary circumstances, inasmuch as by Montgolfier's formula (which is founded on the fundamental formula $v = \sqrt{2gs}$)

$$v = \sqrt{\frac{2gh\,(t - t^1)}{492}}$$

$h =$ distance between top of chimney and floor of room in question, and thus the velocity with which air enters is governed by the difference between the internal and external temperature, and the height from which the cold air descends in order to take the place of the air which has escaped.

APPENDIX TO CHAPTER XXV.

PROBLEMS AS TO FLOW IN SEWERS.

Sewers.—In order to prevent deposit of solid matter, sewers should be constructed with a sufficient gradient, and of a shape which presents the least surface for friction in proportion to the amount of liquid to be conveyed. Where the gradient is not good, the sewer must be regularly flushed by locks or flushing gates which retain the sewage for a time, and when set free suddenly flush the next section of sewer; or by filling the manhole at the head of a section of a sewer with water, and then suddenly releasing the water.

All brick sewers should be egg-shaped, with the narrow end downwards. The egg is formed by two circles touching one another, the diameter of the upper circle being twice that of the lower.

This shape possesses the great advantage that when the depth of the stream is diminished the amount of wetted surface of sewer (*wetted perimeter*) is diminished in equal proportion, whereas in every other form of sewer it is relatively increased. Thus the friction, which depends on the extent of the wetted perimeter, is kept down to a minimum. Where, as in outfall sewers, the volume of of sewage is large, and does not vary greatly in amount, the circular form may be preferable, as it is cheaper and stronger than the egg-shaped sewer. Below 18 inches internal diameter, sewers should be circular in section, and made of stoneware, not brick.

The *velocity of flow* depends upon (1) the hydraulic mean depth of the stream, and (2) its inclination or fall.

The *hydraulic mean depth* means the depth of a rectangular channel whose sectional area (and therefore the volume of whose current) equals that of the curved sewer or pipe, concerning which the calculation is made, and whose width equals the entire wetted perimeter of the sewer or pipe. It is thus equal to $\frac{\text{sectional area.}}{\text{wetted perimeter.}}$

In the case of circular pipes, if we take the diameter to be 1, and assume the pipe to be running full, the sectional area $= \pi r^2$, where $\pi = 3{\cdot}1416$ and $r =$ half diameter.

The wetted perimeter $= 2\pi r$, that is, the circumference of the circle formed by the pipe.

Therefore hydraulic mean depth $= h = \dfrac{\pi r^2}{2\pi r} = \frac{1}{4}$

similarly when the pipe runs half full

$$h = \frac{\dfrac{\pi r^2}{2}}{\dfrac{2\pi r}{2}} = \tfrac{1}{4}$$

The solution of problems where a smaller arc of a circle is occupied by fluid requires trigonometrical methods, and is not usually needed in practice.

The *quantity of fluid discharged* in a given time is represented by the product of the sectional area of the stream into its velocity. The greater the hydraulic mean depth the greater is the velocity, if the inclination remains the same.

The *velocity of flow* is determined by Eytelwein's formula, which states that the mean velocity per second of a stream of water similar in form to those now under consideration is nine-tenths of a mean proportional between the hydraulic mean depth and the fall in two English miles, if the channel were prolonged so far.

Thus if $f =$ the fall (in feet) in two miles,

$h =$ hydraulic mean depth in feet,

$V =$ mean velocity per second.

Then $V = {\cdot}9\sqrt{h.f.}$

or if $v =$ velocity per minute, then

$v = 55\sqrt{h.f.}$

It is more convenient to let $f =$ fall in one mile.

Then the formula becomes $v = 55\sqrt{h \times 2f.}$

What is the velocity of flow of sewage in a 6-in. pipe running half full, and having a fall of 1 in 60; and what would be the discharge per minute in cubic feet and in gallons?

$$6 \text{ inches} = \tfrac{1}{2} \text{ foot.}$$
$$r = \text{radius} = \tfrac{1}{4} \text{ foot.}$$
$$h = \frac{\frac{\pi r^2}{2}}{\frac{2\pi r}{2}} = \frac{\pi r^2}{2\pi r} = \frac{r^2}{2r} = \tfrac{1}{8}$$

1 in 60 = x in one mile.
= x in 5,280 feet.

Therefore 1 in 60 = 88 in one mile.

$$v = 55\sqrt{h \times 2f} = 55\sqrt{\tfrac{176}{8}}$$
$$= 253 \text{ feet per minute.}$$

The amount of fluid discharged per minute = sectional area × velocity.

$$= \frac{\pi r^2}{2} \times 253$$
$$= \frac{3{\cdot}1416}{32} \times \tfrac{253}{1} = 24{\cdot}83 \text{ cubic feet.}$$

But one cubic foot of water = 6·24 gallons (one gallon = ·16 cubic foot).

Therefore amount of fluid discharged per minute = 154·97 gallons.

What will be the flow of water through a 3-in. pipe 1,000 feet long running full, with a loss of head between the two ends equal to 5 feet?

(Edin. Univ. B.Sc. in Pub. Health, 1883.)

Here $h = \frac{\pi r^2}{2\pi r} = \frac{r}{2}$, in a pipe running full.

Diameter = $3'' = \tfrac{3}{12} = \tfrac{1}{4}' \therefore$ radius = $\tfrac{1}{8}'$

$$h = \frac{r}{2} = \frac{1}{8 \times 2} = \tfrac{1}{16}$$

Fall of 5 feet in 1,000 = x feet in 5,280 (one mile)
= 26 feet in mile

$$v = 55\sqrt{h \times 2f}$$
$$= 55\sqrt{\tfrac{52}{16}}$$
$$= 99 \text{ feet per minute.}$$

But if s = sectional area of stream

$v \times s$ = cubic feet of water discharged per minute.

$$s = \pi r^2$$
$$= \frac{3{\cdot}1416}{64}$$
$$v \times s = \frac{99 \times 3{\cdot}1416}{64} = 4{\cdot}86 \text{ cubic feet} = 30{\cdot}3 \text{ gallons.}$$

How much sewage will a circular drain 3 feet in diameter running half full convey, the fall being 1 in 400? *(Edin. Univ. B.Sc., 1875.)*

$$\text{Here } h = \frac{\frac{\pi r^2}{2}}{\frac{2\pi r}{2}} = \frac{r}{2} = \frac{3}{4}$$

1 in 400 = x in 5,280 feet (*i.e.*, a mile)

$$f = 13\cdot2 \text{ in a mile}$$
$$v = 55 \times 4\cdot4 = 242 \text{ feet per minute}$$
$$= 55\sqrt{h \times 2f}$$
$$S = \frac{\pi r^2}{2} = \frac{3\cdot1416 \times 9}{4 \times 2} = 3\cdot5343$$

$v \times S = 242 \times 3\cdot5343 =$ 855·8 cubic feet, discharged per minute.

In what way does the size and shape of a sewer affect the velocity of the sewage flowing through it? If a 12-inch pipe sewer, laid at a gradient of 1 in 175, gives a velocity of $3\frac{1}{2}$ feet per second, what would be the velocity if the sewer had a gradient of 1 in 700 (the pipe running half full in each case); and would this latter velocity suffice to keep the sewer clear of deposit?

(Exam. Sanitary Institute for Surveyors, 1887.)

An elliptical sewer gives greater velocity of flow to small quantities of sewage than a circular one because it exposes a smaller surface for friction.

By formula $= v = 55\sqrt{h \times 2f}$

$$h = \tfrac{1}{4} \therefore \sqrt{h} = \tfrac{1}{2}$$
$$f = 1 \text{ in } 175 = 30 \text{ feet in one mile}$$

$v = \frac{55}{2}\sqrt{60} = 212\cdot85$ ft. per min., *i.e.*, slightly over $3\frac{1}{2}$ ft. per [sec.

In the second case $f = 1$ in $700 = 7\cdot56$ feet in one mile.

$$v = \tfrac{55}{2}\sqrt{15\cdot12} = 106\cdot97 \text{ feet per minute.}$$

Thus in the first case there is a velocity of 3·55 feet per second, and in the second case of 1·78 feet per second. The latter velocity is quite insufficient to keep the sewer free from deposit, 3 feet per second being the minimum velocity required for that purpose.

Given a sewer 3 feet in diameter, with a fall of 1 in 1,760, what would be the relative discharge if the fall were 1 in 5,280?

In first case 1 in 1,760 = 3 in mile

1 in 5,280 = 1 in mile

$$h = \frac{r}{2} = \frac{3}{4}$$
$$v = 55\sqrt{h \times 2f}$$
$$= 55\sqrt{\tfrac{3}{4} \times 6} = \frac{165}{\sqrt{2}} = 118.$$

In second case $v = 55\sqrt{\frac{3}{4} \times 2} = 55\sqrt{\frac{3}{2}} = 67{\cdot}9$.

Thus the velocity of the two streams would be as 118 : 67·9.

Supposing a sewer to have a gradient of 1 in 300, how much would the velocity and discharge be increased by altering the gradient to 1 in 100?

(Sanitary Institute Exam. for Surveyors, 1886.)

1 in 300 = 17·6 in mile.
1 in 100 = 52· in mile.

As h is not given, we must assume it $= \frac{1}{4}$, as it does in circular sewers running full or half full.

$$v = 55\sqrt{h \times 2f}$$

$$= 55\sqrt{\frac{35{\cdot}2}{4}} = 163 \text{ feet per minute.}$$

$$v^1 = 55\sqrt{\tfrac{104}{4}} = 281\cdot \quad ,, \quad ,,$$

The increase in discharge may be similarly calculated.

Describe the relation existing in a sewer between gradient, volume, velocity and size. *(Exam. Sanitary Institute for Local Surveyors, 1889.)*

By the formula $v = 55\sqrt{h\,.\,f}$.

Where v = velocity in feet per minute

h = hydraulic mean depth $= \frac{\text{area of cross section of stream}}{\text{wetted perimeter}}$

f = fall in feet in two miles.

In circular sewers $h = \frac{\text{diameter}}{4}$.

Thus the velocity varies as the square root of h or f.

The volume discharged varies with the value of the factor $v \times s$ where s = sectional area of stream.

If h remains constant, with a varying value of s, then the volume discharged may remain constant. Thus h and v in a circular sewer are the same, whether the sewer runs full or half-full. In a V-shaped channel the velocity remains the same whatever the depth of the stream, as its bed and area preserve the same proportions. An egg-shaped sewer approximates the V shape in form.

Similar volumes of sewage have velocities which vary not only with the amount of fall, but the size of the sewer. The friction, as represented by the wetted perimeter, would be much less with sewage half-filling a circular sewer, than with the same amount of sewage forming a broad shallow stream on the invert of a larger sewer.

APPENDIX TO CHAPTER XXXIII.

PROBLEMS AS TO EXERCISE.

The amount of carbonic acid gas eliminated is greatly increased by exercise. Dr. Edward Smith's experiments gave the following results:—

	AMOUNT OF CO_2 ELIMINATED PER MINUTE	PROPORTIONS, TAKING AMOUNT DURING REST AS UNITY
During rest	13·11 grains	1
Walking at two miles per hour and carrying 7 lbs.	24·26 ,,	1·85
Walking at 3 miles per hour ...	34·66 ,,	2·64
On tread-wheel, when lifting 196 lbs. through 1,920 feet per hour	57·68 ,,	4·40

The experiments of Pettenkofer and Voit, which were carefully made, show the following results as regards the daily absorption of oxygen and the elimination of carbonic acid, water, and urea.

	ABSORPTION OF OXYGEN IN GRAMMES	ELIMINATION IN GRAMMES OF		
		CARBONIC ACID	WATER	UREA
Rest-day	708·9	911·5	828·0	37·2
Work-day	954·5	1284·2	2042·1	37·

The increased elimination of carbonic acid during active work renders necessary a greater supply of fresh air under these circumstances than is necessary in bedrooms or private houses generally.

The *amount of work done* by a healthy adult per diem is variously stated by different physiologists. It is stated by M. Foster to be about 150,000 metre-kilogrammes (*i.e.*, 150,000 kilogrammes lifted 1 metre). Metre-kilogrammes can be converted into foot-pounds by multiplying by 7·233; into foot-tons by multiplying by ·003229;

150,000 metre-kilogrammes therefore equal 484·35 foot-tons. This is considerably in excess of Dr. Parkes' estimate (given page 323), but in certain laborious occupations this high amount is reached.

In addition to this amount of external work, there is the internal work of the heart, muscles of respiration, digestion, etc. This is estimated by Parkes at about 260 foot-tons.

The internal and external muscular work of the body together amount to about 1—7th to 1—8th of the total force obtainable from the food.

Professor Haughton has shewn that the work done by a man walking on a level surface at the rate of three miles an hour is equivalent to raising his own weight, *plus* the weight he carried, through $\frac{1}{20}$ of the distance walked.

Thus, if W = weight of the man,
W^1 = weight carried by him,
D = distance walked in feet,
C = co-efficient of traction ($\frac{1}{20}$ at three miles an hour),
then we obtain by the following formula the amount of work done, the co-efficient of traction being multiplied by 2,240 (the number of pounds in a ton) to obtain the result in foot-tons.

$$\frac{(W + W^1) \times D}{C \times 2,240}$$

In ascending a height, a man raises his whole weight through the height ascended.

A regiment of soldiers marches ten miles, each carrying a weight of 60 *lbs.* (*nearly the weight a soldier carries when in marching order*). *What amount of work is performed by each soldier?*

If we assume the average weight of each soldier to be 150 lbs., and that the march was at the rate of three miles an hour, then—

$$\frac{(150 + 60) \times 10 \times 5\cdot280}{20 \times 2,240} = \underline{247\cdot5} \text{ foot tons.}$$

This represents a moderate day's work.

In this example it is assumed that the march is on entirely level ground, that all weights are carried in the most convenient manner, and that the rate of travel is three miles an hour. Velocity is gained at the expense of

carrying power. It has been found that the amount of work is generally inversely as the square of the velocity. Dr. Haughton has determined from Weber's calculations the co-efficient of resistance for three velocities.

Velocity.	Co-efficient of Traction or Resistance.
1·818 miles per hour	$\frac{1}{28\cdot27}$
4·353 " "	$\frac{1}{13\cdot70}$
10·577 " "	$\frac{1}{7\cdot51}$

Dr. Parkes has extended these calculations and gives the following table to show the distance required to be travelled at various velocities to do work equal to 300 foot-tons, and the time required in each instance.

Velocity in Miles per Hour.	Co-efficient of Resistance.	Distance for Men of 160 lbs. to equal 300 foot-tons.	Time required in Hours and Minutes.
			hrs. mins.
2	$\frac{1}{26\cdot74}$	12·2	10 ... 36
3	$\frac{1}{20\cdot59}$	16·3	5 ... 24
4	$\frac{1}{16\cdot74}$	13·3	3 ... 18
5	$\frac{1}{14\cdot10}$	·2	2 ... 36
6	$\frac{1}{12\cdot18}$	9·6	1 ... 36
7	$\frac{1}{10\cdot72}$	8·5	1 ... 12
8	$\frac{1}{9\cdot60}$	7·6	0 ... 57
9	$\frac{1}{8\cdot65}$	6·9	0 ... 40
10	$\frac{1}{7\cdot89}$	6·3	0 ... 38

The co-efficient $\frac{1}{20}$ corresponds very nearly to 3·1 miles per hour, and it appears that at this rate of travel the greatest amount of work can be done with the least expenditure of energy.

How much work is done by a man walking at 4 miles an hour, a distance of 15 miles; his weight and weight he carries equalling together 12 stone, 8 lbs.?

$$\frac{176 \times 15 \times 5{,}280}{16{\cdot}74 \times 2{,}240} = \underline{371{\cdot}7 \text{ foot-tons.}}$$

How much work is done by a man weighing 150 lbs. who walks 15 miles up an incline 1 in 200?

The amount of feet ascended in 15 miles

$$= \frac{5{,}280 \times 15}{200} = 396.$$

The amount of work done by the man in raising his own weight 396 feet high

$$= \frac{396 \times 150}{2{,}240} = \underline{26{\cdot}5 \text{ foot-tons.}}$$

The amount of work done in walking 15 horizontal miles at the rate of 3 miles an hour

$$= \frac{150 \times 15 \times 5{,}280}{20 \times 2{,}240} = 265{\cdot}2 \text{ foot-tons.}$$

Total amount of work done = 265·2 + 26·5

$$= \underline{291{\cdot}7 \text{ foot-tons.}}$$

Eight palanquin bearers carry an officer weighing 180 lbs. and a palanquin weighing 250 lbs., a distance of 25 miles. Assuming that each man weighs 150 lbs., what amount of work was done by each man? (Parkes.)

$$\begin{aligned} 250 + 180 &= 430 \\ 150 \times 8 &= 1{,}200 \\ \hline W + W^1 &= 1{,}630 \end{aligned}$$

$$\frac{1{,}630 \times 25 \times 5{,}280}{20 \times 2{,}240} = \underline{4{,}802{\cdot}7 \text{ foot-tons.}}$$

This being the total work done, the work per man = nearly 600·3 foot-tons.

A hill-coolie weighing 150 lbs. goes 30 miles with an ascent of 5,500 feet in three days, carrying 80 lbs. weight. What is the work per day? (Parkes.)

$$\text{Work of the ascent} = \frac{(150 + 80) \times 5{,}500)}{2{,}240} = 564{\cdot}7 \text{ foot-tons.}$$

$$\text{Work of 30 miles walk} = \frac{230 \times 30 \times 5{,}280}{20 \times 2{,}240} = 813{\cdot}2 \text{ foot-tons.}$$

Total work = 564·7 + 813·2 = 1,377·9.

Total work per day = $\frac{1377{\cdot}9}{3}$ = $\underline{459{\cdot}3 \text{ foot-tons.}}$

If a man 20 stone in weight and carrying 20 lbs. weight, walks 10 miles per day up a hill which is 500 feet high, what work does he do?

$$\frac{(280 + 20)\ 10 \times 5280}{20 \times 2240} = 353{\cdot}5 \text{ foot tons}$$

$$500 \times 300 = 150{,}000 \text{ foot pounds} = 67 \text{ foot tons}$$

$$\text{Total work done} = \underline{420{\cdot}5 \text{ foot tons.}}$$

If a man 180 lbs. in weight, wishes to expend 200 foot tons of energy, how far must he walk?

$$\frac{180 \times D}{20 \times 2240} = 200$$

$$\text{Therefore } D = \underline{9{\cdot}4 \text{ miles.}}$$

Suppose a man weighing 150 lbs. in his clothes, carries a load of bricks weighing 35 lbs. up a perpendicular ladder 30 feet high, 100 times daily, what amount of work does he do; and what will it equal in miles walked upon a flat road at the rate of 3 miles an hour?

$$\frac{(150 + 35) \times 30 \times 100}{2240} = 247{\cdot}8 \text{ foot tons}$$

$$\frac{185 \times D}{20 \times 2240} = 247{\cdot}8$$

$$\text{Therefore } D = 60056 \text{ feet}$$

$$= \text{about } \underline{11{\cdot}4 \text{ miles.}}$$

How much exercise ought to be taken daily for health? How is work calculated? Suppose a man strikes 12,000 strokes in 5 hours with a 14-lb. hammer, raising it at each stroke 4 feet, how much work does he do? Compare this with a walk of 15 miles on a level ground at 3 miles an hour, the weight of the man and what he carries being 180 lbs.—(University of London: Public Health Examination, 1884.)

(*a*) $12000 \times 14 \times 4 = 672000$ foot lbs. of work

$= 300$ foot tons

(*b*) $\dfrac{180 \times 15 \times 5280}{20 \times 2240} = 318{\cdot}2$ foot tons

The two amounts of work are related as $\underline{300 : 318{\cdot}2.}$

ADDITIONAL SUBJECTS.

It has been found impossible to give, within the scope of this work, details on two important questions within the syllabus of the Honors Stage of the Science Department in Hygiene, viz., Vital Statistics and the Laws relating to Sanitary matters.

On the first of these, the Author's *Elements of Vital Statistics* (7/6) should be read, as it contains all the requisite information.

On the second, the most convenient work is *Hime's Handy-Book of Public Health* (Baillière, Tindal & Cox), which contains a summary of the more important Acts of Parliament relating to the Public Health.

The model bye-laws of the Local Government should be carefully studied. For this purpose the annotated edition published by Knight & Co., 90, Fleet Street, E.C., is the best.

The subject of School Hygiene has been briefly discussed in various parts of this work; but further details, especially bearing on the relationship of Eyesight to School Life, may be found in the Author's *School Hygiene; the Laws of Health in relation to School Life.*

INDEX.